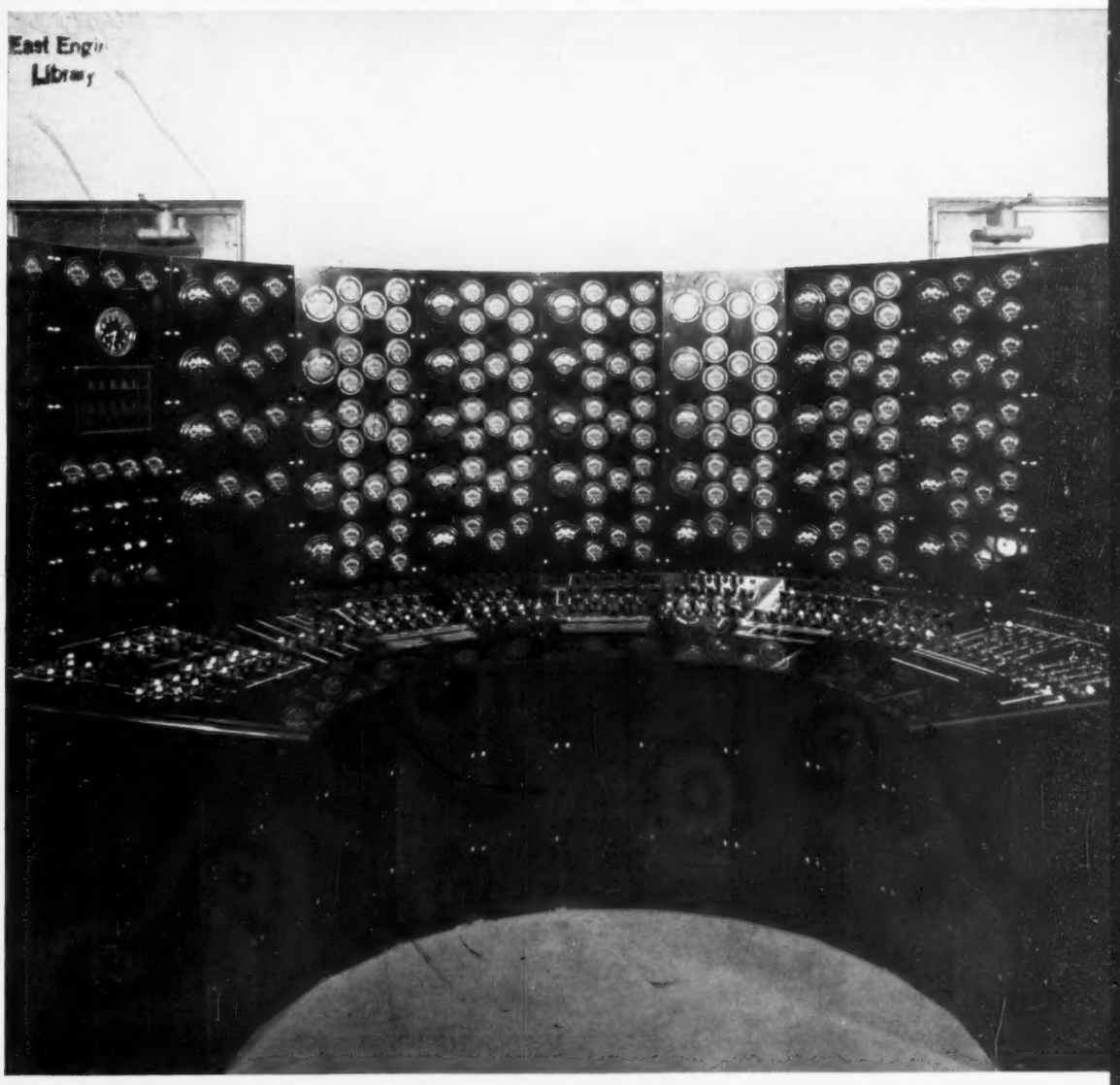
THE MAGAZINE OF

MEASUREMENT and CONTROL

INSTRUMENTS

East Engi
Library



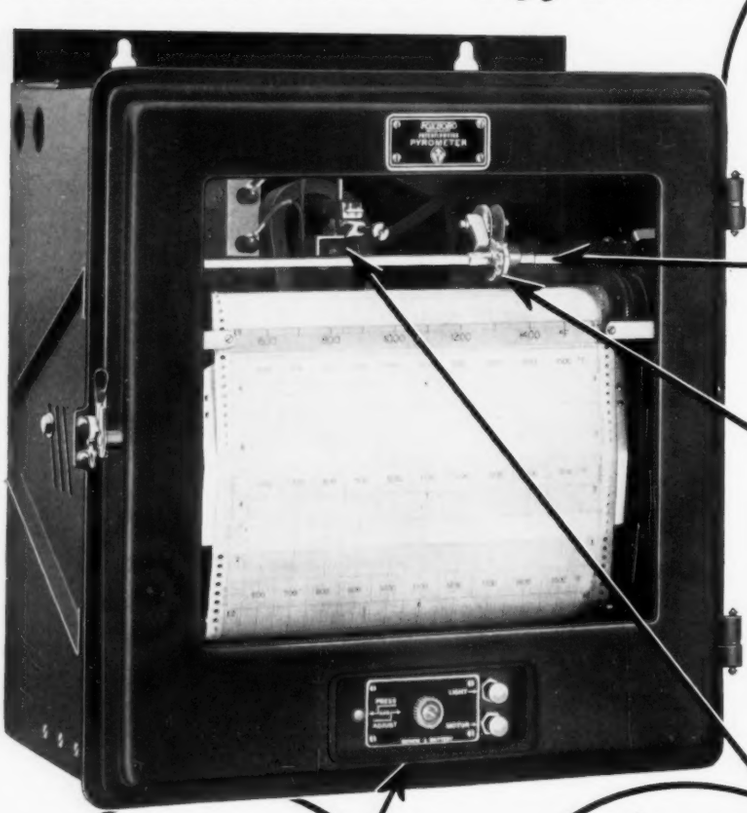
BENCHBOARD AT NEW STATION TEN (HOLLYWOOD) LOS ANGELES
(Courtesy Bureau of Power & Light, City of Los Angeles)

TWO ARTICLES ON
IMPROVED METHODS OF FAULT LOCATION
See pages 69 and 73

VOLUME 9
MAR.
1936
NUMBER 3

Improved Again!

The Foxboro Potentiometer Recorder *Now Offers:*



Extra Compensating Slide-Wire

assures uniform balancing action and pen travel at any point on the chart. (A new, exclusive Foxboro development.)

Integral Slide-Wire Contact Mounting

No errors due to lost motion between slide-wire contact and recording mechanism. Another original Foxboro development.

Operating Adjustments Outside

On recessed panel are light switch and motor switch, and the new standardizing rheostat which assures quick, precise standardizing.

Large Precision Galvanometer

Suspensions are both adjustable and replaceable, and are almost twice ordinary length, for strength with sensitivity.

New Bulletin

No. 190-1 illustrates the many other improvements. Send for your copy today—no obligation. The Foxboro Company, 46 Neponset Ave., Foxboro, Mass., U. S. A.

Branches in 20 Principal Cities

POTENTIOMETERS
Indicating
Recording
Controlling

MILLIVOLTMETERS
Indicating
Recording

ELECTRIC RESISTANCE THERMOMETERS
Indicating
Recording
Controlling

FOXBORO
REG. U.S. PAT. OFF.
PYROMETERS

• COMPLETE INDUSTRIAL INSTRUMENTATION •

TEMPERATURE CHANGES TRANSMITTED

6 TIMES FASTER

with New Taylor Thermospeed Tube System . . .

New Separable Well Tube System construction many times more sensitive than conventional types . . . overcomes sluggish and lagging response and reduces bulb conduction error.

A SEPARABLE WELL Tube System with a rate of response to temperature changes that closely equals that of a fast-acting, bare-bulb system.

This is the latest contribution of Taylor Engineers to more accurate temperature measurement and control. And one of the most important!

The Taylor Thermospeed Tube System overcomes the sluggish action common to previous Separable Well Systems. The Thermospeed construction speeds up response. It enables Taylor Recording Thermometers to show a true and accurate picture of temperature at the bulb—and do it on the dot. It causes control valve corrections to be made at the slightest tendency to depart from the control point. It enables Taylor Controllers to give much closer regulation, especially where rapid temperature changes occur.

Remember this point, too. The Taylor Thermospeed construction assures more accurate control by greatly reducing bulb conduction error. Variation in the temperature of the bulb mounting or supporting wall does not change the bulb temperature. Another disadvantage of previous separable well systems overcome at last!

The graph indicates how much faster Thermospeed is in response than other types of separable well instruments. But don't stop with reading about it. Let us demonstrate how this new Taylor development can modernize and sharpen temperature control wherever separable wells are necessary. This service is available from a Taylor Representative. Or can be obtained by writing to Taylor Instrument Companies, Rochester, N.Y., or Toronto, Canada. Manufacturers in Great Britain—Short & Mason, Ltd., London, England.

New Taylor Thermospeed construction (separable well and bulb) shown with Taylor Fulscope Controller.

PASS IN REVIEW

Here are just a few of the developments that have come to industry from Taylor Engineers within a comparatively short time.

Accuratus Tubing, which has made Taylor mercury-actuated tube systems applicable almost anywhere.

"Fulscope" Recording Controllers with the Universal Sensitivity Adjuster.

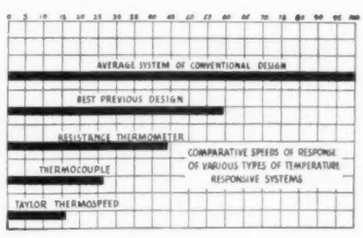
"Dubl-Response" Control, which assures accurate load compensation and Precision Valve Action.

"Valve-Precisor," a separate precision-valve-action unit to modernize control valves now in operation.

And the *Thermospeed* Separable Well Tube System described here.

Let Taylor Engineers find the answers to your temperature problems and needs.

Showing the comparative rates of response of various temperature measuring devices plotted to an arbitrary time scale. In response to the same temperature change, the THERMOSPEED is six times faster than the average conventional tube system; about three times faster than a resistance thermometer; and almost twice as fast as a thermocouple.


AVERAGE SYSTEM OF CONVENTIONAL DESIGN
BEST PREVIOUS DESIGN
RESISTANCE THERMOMETER
THERMOCOUPLE
TAYLOR THERMOSPEED
COMPARATIVE SPEEDS OF RESPONSE OF VARIOUS TYPES OF TEMPERATURE RESPONSIVE SYSTEMS

Taylor

Indicating Recording · Controlling

TEMPERATURE, PRESSURE *and* **FLOW INSTRUMENTS**

INSTRUMENTS The Magazine of MEASUREMENT and CONTROL

CONTENTS · MARCH 1936

Front Cover: New Benchboard at L. A.
Courtesy Los Angeles Bureau of Power & Light

New Fault Location Method 69
for Overhead Transmission Lines
By J. E. Allen

Accurate Fault Location 73
on Communication Lines
By C. E. Clutts

Production Control Tests 75
Make Them in the Plant!
By G. E. Hann

Cathode-ray Tube Auxiliaries 77
Ninth part of Oscillography series
By R. R. Batcher

Totalizing 82
Second part of two on this subject
By Perry A. Borden and M. F. Béhar

INSTRUMENTS' READERS AT WORK
No. 3—John Joseph Grebe)
No. 4—Robert W. Cermak 58
No. 5—Ray H. Boundy)

NEW INSTRUMENTS 59
Indicators, recorders, controllers, inspection devices, etc., for the plant and laboratory

OTHER DEPARTMENTS, etc.

EDITORIAL COMMENT 57
INSTRUMENTS' BOOK SHELF 72
MANUFACTURERS' NEW LITERATURE 85
ADVERTISERS' INDEX 89
BUYERS' GUIDE 90

RICHARD RIMBACH
Managing Editor

M. F. BEHAR
Editor

EDITORIAL ADVISORY BOARD
G. BERNDT
Technische Hochschule, Dresden
W. G. BROMBACHER
National Bureau of Standards
A. V. DeFOREST
Massachusetts Inst. of Technology
K. J. DeJUHASZ
Pennsylvania State College
PAUL B. FINDLEY
Bell Telephone Laboratories
JOHN L. HAUGHTON
National Physical Laboratory, England
H. L. HAZELTINE
Sterling Varnish Company
C. A. HEILAND
Colorado School of Mines
GEORGE KEINATH
Editor, Archiv fuer Technisches Messen
E. S. LINCOLN
Consulting Electrical Engineer
JOSEPH LYNCH, S.J.
Seismic Station, Fordham University
FOSTER D. SNELL
Consulting Chemist
THOMAS SPOONER
Westinghouse Research Laboratories
S. R. WILLIAMS
Amherst College

Published Monthly on the 15th by
The Instruments Publishing Company
1117 Wolfendale Street Pittsburgh, Pa.
JOSEPH J. VIGNEAU, President
RICHARD RIMBACH, Vice-Pres.-Treas.

Branch Offices
Boston: James Condon, 6 Marlboro St.
New York: Edwin F. Ripley, 118 E. 28th St.
Chicago: R. Farnham, 201 Wells St.
Glendale, Calif.: W. McIntyre, 1115 Tyler St.

Annual Subscription: U. S. $2.00. All other countries $3.00 *payable in advance* (remit by New York draft).

Copyright 1936 by The Instruments Publishing Company.

Entered as second-class matter January 26, 1932, at the post office at Pittsburgh, Pa., under the Act of March 3, 1879.

INSTRUMENTS The Magazine of MEASUREMENT and CONTROL

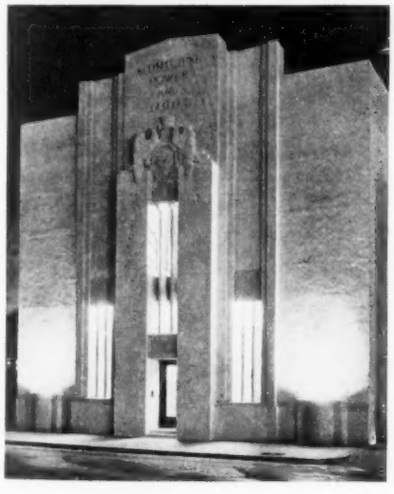
M. F. BEHAR
EDITOR

THE FRONT COVER

It seems that we have unknowingly been running in *Instruments* a department without a printed title: a Fashion Department! We are told that our taste in selecting photographs of instrument boards for front-cover display has become an "influence" and that if we were to show one particular "style" several months in succession, it would just about ruin some manufacturers and enrich others!

Our friend exaggerates. *Instruments* does wield a little influence, to be sure, but neither in kind nor in degree like that which makes millions of women buy hats as worn by Hollywood stars.

What made us think of Hollywood? The fact that we received from the Los Angeles Bureau of Power and Light two photographs of their new Number Ten (Hollywood) station: the outside view



reproduced here and the view of the benchboard reproduced on this month's front cover. The panels, left to right, are as follows:

No. 1 Carrier current (700 cycles) street light control;

No. 2. Battery charging and station service;

No. 3. Station service, spares, incoming lines;

No. 4. Transformer banks and 4600-volt feeders.

Instruments are Weston types "429" and "476."

We quote from the letter of transmittal: " . . . latest type benchboard . . . latest in station design . . . "

IN THIS ISSUE

YOUR interest in the New Instruments Department is being attested so unmistakably on your questionnaires now coming in, that we are placing this department in front of the feature articles. Do you like this re-arrangement? Since we aim to serve you in every possible way, we invite your frank comments.

(Note: If you have not returned your questionnaire, please do so at your earliest convenience.)

To J. E. Allen and G. J. Gross went the 1935 James H. McGraw Award, for their joint paper on a new method of fault location. Mr. Allen now contributes to *Instruments* a specially-written description of this method. The ideal "companion article" on fault location, however, was not written exclusively for *Instruments* and it is through the courtesy of Editor P. B. Findley of the *Bell Laboratories Record* that we publish C. E. Clutts' description of methods whereby fault location uncertainty can be reduced from furlongs to feet. The work of Allen in energy transmission, and that of Clutts in telephony, might remain little-known outside of their respective fields. It is a function of Instrumentation to unite; it is a function of *Instruments* to correlate.

President Theodore Roosevelt once promised that he would "sift to the bottom" an alleged crooked deal but, unable to do it himself, he delegated the job, whereupon some newspapers chided him mercilessly. One cartoon we still remember pictured a series of buck-passings, the last one showing an office boy tossing a sheaf of documents into a waste basket. When channels of authority and information get clogged in large plants—and in some small ones—overhead and production costs go up, especially if shops and laboratories work at cross-purposes. G. E. Hann tells how to prevent such mix-ups by distributing both information and instruments among selected laborers, to make them understandingly quality-conscious.

More accessory devices for cathode-ray tubes are described by R. R. Batcher in his oscillography serial.

And more totalizing methods are discussed in this month's electrical-measurements instalment — including as usual some which Perry Borden, during his long experience, worked with at first-hand.

A number of book reviews are scattered throughout this issue. (Number and scattering are signs of Spring.)

And sixty-two new manufacturers' catalogs, booklets bulletins and leaflets are reported on pages 85 and 86.

INSTRUMENTS' READERS AT WORK

No. 3 JOHN JOSEF GREBE
Director of Physical Research Laboratory

No. 4 ROBERT W. CERMAK
In Charge of Instrument Department

No. 5 RAY H. BOUNDY
Ass't to Director Physical Research Lab.

The Dow Chemical Co., Midland, Mich.

By M. F. BEHAR

WE respectfully request you, Doctor Grebe, to overcome that camera-shyness of yours. Come, now, John, surrender!

All right, but I'll dictate the terms of capitulation. You say you want to show me at my work. You mean specifically at my Instrumentation work?

Yes: as you actually plan and direct this ever-growing instrumentation of the Dow plants.

Then the picture, to be in accord with the facts of 1936, must not show me alone: Boundy and Cermak now do 99% of the instrument work proper. You see, I have less time for it.

I can imagine, for I know of your thirty-odd patents on extracting bromine from sea water, thermal cycles, chemical treatments of oil wells and—

As I was saying, Boundy came with us after graduating from Case School of Applied Science in 1926, worked with me from the beginning in the development of special control systems and is following up all the electrometric work, that is to say all controls involving chemicals and solutions. Cermak has worked with us since graduating from Case in '29 and now has charge of the instrument service and repair for all the chemical processes. My instrument work is done with them.

Now I remember, you three jointly wrote that recent A.I.C.E. paper on the control of chemical processes. More than forty pages of penetrating and thorough—

Never mind! To conclude: the instrument work for the power plants is not under us but is handled by Mr. Lester Friedel.

But you are supposed to be the subject of our next sketch. I want to mention your activity in half a dozen scientific and engineering societies, your receiving an honorary degree—

Quite unnecessary!

Then, too, this series of sketches covers only the actual readers of *Instruments*, particularly our charter subscribers. The names on our old subscription records—

They don't apply in the case of our company, where your magazine has been circulated and studied and referred to by men responsible for the instrument work ever since its first number came out. We're all readers, as you can see from the wear of this copy on my desk.

INSTRUMENTATION OF DOW CHEMICAL CO.'S PLANT

486 temperature indicators and recorders of various types;
64 automatic temperature controllers (not counting thermostats);
72 electrometric recorders and automatic controllers, for hydrogen ion, oxidation potential, gas analysis, conductivity, and specific gravity—all of special design;
15 flow indicators, recorders, and automatic controllers;
5 time recorders;
147 pressure recorders and automatic controllers;
20 level recorders;
5 recording voltmeters;
18 draft indicators;
2 recording psychrometers.
Several hundred portable instruments for testing, checking, and experimental set-ups.

"In use throughout the plant but not included in the above list are a great many instruments of various kinds requiring only occasional attention."—J.J.G.

The Dow "Instrumentriumvirate." Left to right: Cermak, Grebe, Boundy. The shiny gadget deserves attraction, for it is their famous "control block" whereby they solved extraordinarily difficult process-control problems requiring automatic reversal of controlled valve before indication crosses normality, and recognition of unusual combinations of second-derivative time factors.

THE MONTH'S NEW INSTRUMENTS

In this department we strive to report each month ALL the new devices for measurement, inspection, testing, metering and automatic control—in the form of concise technical descriptions.

When writing to manufacturers directly, please mention this department as your source of information.

Or write to Information Section, Instruments Publishing Company.

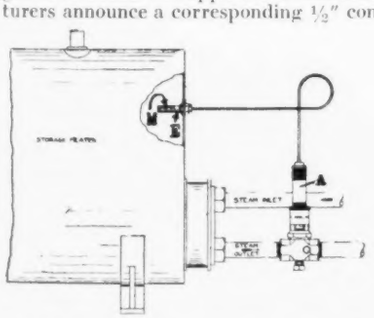
Wear Testing Machine

Designed to simulate practical conditions of friction and wear between two non-lubricated surfaces—*e.g.*, wear of rails and car wheels. Friction qualifications are arrived at by measuring the amount of metal removed through wear at various conditions of speed and load

for materials of different analysis, heat-treatment and hardness. The two wear test specimens are rectangular, approx. 2"x1" and ½" thick. One is being held rigidly in a slide; the other in a gripping head connected to the loading mechanism. Slide has a maximum stroke of 1", is attached to an eccentric shaft connected to a variable-speed drive and a two-speed motor. Testing speeds may be regulated in stepless intervals between 25 and 300 double strokes per minute. Total load on specimen may be varied in stepless intervals between 20 and 2000 lbs., or between 10 and 1000 lbs./in.^{2} load on the specimen.—*Riehle Div., Am. Machine & Metals Mfg. Co., East Moline, Ill.*

Self-operating Temperature Controller

Supplementing their line of automatic gas valves for control of temperature in gas-fired industrial appliances, manufacturers announce a corresponding ½" con-

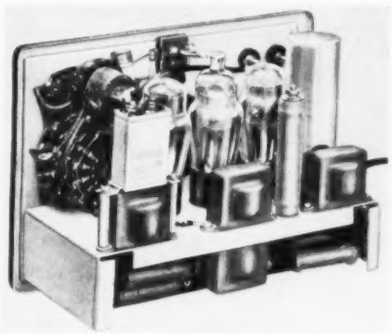


trol valve for steam-heated equipment. It is of the throttling type, with bulb-and-bellows thermal system. Valve body is of cold rolled steel, disk and seat of Monel, stem of Tobin bronze, bonnet of brass; asbestos-graphited packing in stuffing box. Valve and thermostat are nickel-plated. As illustrated, the "Yarway" control is installed on outlet end of heating coil, to handle condensate. The valve is suitable for steam pressures <125 lbs./in.^{2} and may also be connected to inlet end of coil.—*Yarnall Waring Co., Chestnut Hill, Philadelphia, Pa.*

A-c. Bridge

Permits measurements of inductance (100 μh. to 10 h.), capacitance (10 $\mu\mu$f. to 10 μf.) and resistance (1 ohm to 1 megohm) and hence is designated as maker's

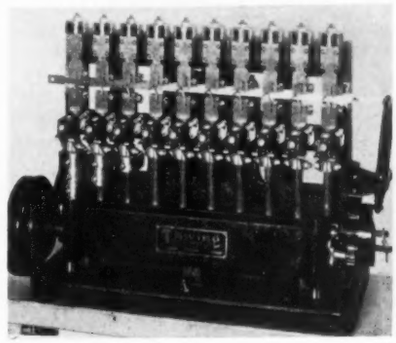
"Universal Bridge." Consists of a variable-ratio-arm a-c. Wheatstone bridge having three standards each for inductance, capacitance and resistance. Includes a vacuum-tube 1000-cycle oscillator and a 2-stage amplifier together with their power supply for operation from 110-120-volt 25-60-cycle a-c. source (power consumption, 40 watts). After proper selection of standard, variable ratio arm permits use of single dial (accuracy at 1000 cycles, 5%). A 9-position 4-gang selector switch permits choice of proper scale; two resistor phasing controls serve to balance out resistance in capacitors and inductors to secure definite null



point; also a variable capacitor for obtaining null point on resistors >100,000 ohms. Only additional equipment required is a null indicator, such as a single headphone of high impedance, >2000 ohms. Case dimensions 9¾"x6½"x4½"; weight 5½ lbs.—*RCA Parts Div., RCA Mfg. Co., Inc., Camden, N. J.*

Multiple Folding Endurance Tester

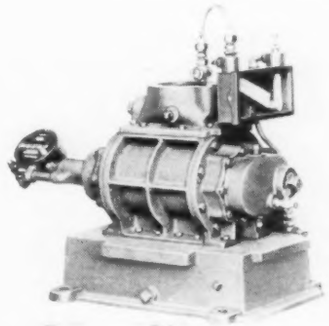
Ten folding tests can be made simultaneously in this new 10-spindle device. Specimens (15 cm. wide as per TAPPI standard) are held in cam-action locking grips and are alternately folded under compression and straightened under



tension. A definite sharp fold is made under the compression load. The compression load is 0.5 kg. Depending upon the grade of paper the tension load may be varied from 0.5 to 3 kg. A tripper folding device alternately folds the paper in two directions. A counter registers the number of folds made to the breaking point. If desired, tests can be made on fewer than ten spindles. A clutch is provided to disengage driving mechanism while test pieces are being inserted in grips. New tester is driven by a motor mounted on the frame, making it portable and operable from electric outlet.—*Thwing-Albert Instrument Co., 3323 Lancaster Avenue, Philadelphia, Pa.*

Dry-type Rotary Meter

Principle, characteristics and various forms of "Connersville" rotary displacement gas meters have been described here (see *Instruments*, April 1933, pages



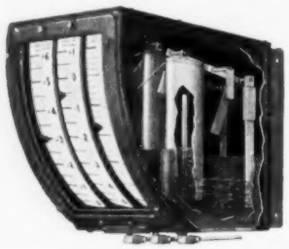
81-83). New small-size model is of <5000 ft.^{3}/hr. capacity when operating with a pressure drop of 1" water. Gear diam. is 2½" and impeller length 7". Dimensions 22"x15"x14". In addition to base illustrated, another is available which permits mounting on a vertical gas line. In addition to inclined-tube manometer and cyclometer register illustrated, recorders, demand devices and other auxiliary instruments are available.—*Roots-Connersville Blower Corp., Connersville, Ind.*

BAILEY METERS

Accurately

Guide and Regulate Process Operations

Multi-Pointer Gages for indicating factors such as draft, pressure, temperature and speed. These gages are available with any number of pointers and any scale combinations from one to twelve. Actuating mechanisms may be oil-sealed bells or diaphragms.



Multi-Pointer Gage

Boiler Meters for recording combustion conditions and guiding boiler operators.

FlowMeters for indicating, recording and integrating the flow of steam, water, sewage, air, gas and other fluids.

Recorders for temperature, pressure, draft, speed and other factors.

Recorder-Controller

Coal Meter

Granular Material Meters for accurately measuring the flow of coal or other granular materials in gravity chutes from overhead bunkers. The total quantity of granular material is shown on a large illuminated counter which may be easily read at a distance of 50 feet.

Control Systems for combustion, flow, pressure, temperature and other factors.

Complete information on any of the above Bailey Products will be gladly furnished upon request.

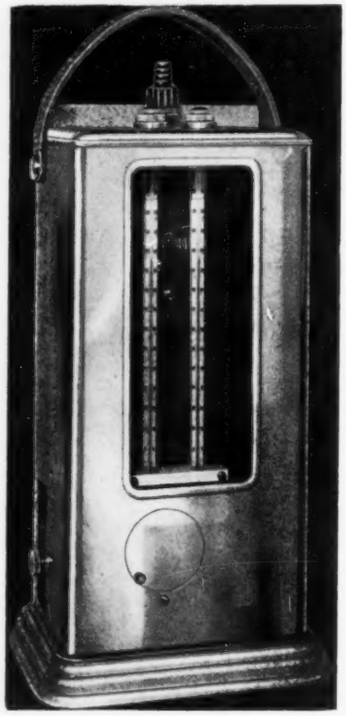
G-2

BAILEY METER COMPANY

1041 Ivanhoe Road • Cleveland, Ohio

Aspiration Psychrometer

Elimination of error due to heat radiation from surrounding objects, including the operator, is achieved in the new electric Thermo-Shield Psychrometer by having the air sample drawn through the top. The initial warmth effect of a wet-bulb reservoir is eliminated by individual applications of water to the wet-bulb for each reading. Entire mechanism is cased in a highly polished chromium plated thermo-shield equipped



with glass window for reading thermometers and an integral rack for psychrometric tables. Thermometers are 10" long, carefully matched, graduated from —5 to +130°F. in 0.5° increments. Fan is operated by a 110 v. a-c. motor. Handled case is approx. 7" square by 13" high.—*Julien P. Friez & Sons, Inc., Baltimore, Md.*

Electronic Capacity Detector

Operates on the approach of a human body, vehicle, etc. Used in connection with automatic spray painting, door control, illuminating dangerous areas upon the approach of a person, truck, or other automatic system where space charge principle can be used. Installation is said to be easily accomplished by the average mechanic: it is only necessary to connect a suitable antenna to the antenna lead-in binding post and "tune" the unit by the two control knobs to the desired sensitivity. A small antenna (6 or 8 ft. long is sufficient to close or open the relay contacts upon the approach of a person within 4 ft. of this antenna. Relay contacts have a capacity of 75 watts non-inductive load. The unit operates from 110-volt a.c. or d.c.—*Electronic Control Corp., 2832 E. Grand Blvd., Detroit, Mich.*

Cathode-ray Oscilloscope

New "Model CRA" has been designed as a general-purpose self-contained cathode-ray oscilloscope, containing facilities

for an unusually wide variety of tests. It contains built-in amplifiers for horizontal and vertical plates giving a sensitivity of 0.4 RMS volts per inch of beam deflection on the 3" cathode-ray tube screen. Linear sweep circuit with Thyratron lock-in circuit permits graphic analysis of all voltage waves. Simplified controls are said to permit easy operation.—*Clough-Brengle Co., 1134-M West Austin Ave., Chicago, Ill.*

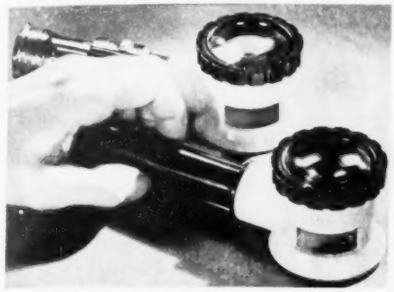
Combination Watthour Meter and Time Switch

For metering and controlling domestic loads including off-peak water heating, new combinations of a watthour meter and a time switch are available as fol-

lows: Either the standard "I-20-A" all-service watthour meter or the "I-20-S" socket-type watthour meter is combined with the "T-28" single-dial with contacts register, with the "T-29" double-dial with contacts register, or with the "T-30" double-dial without contacts register. Accuracy of watthour registration is assured by a positive mechanical gear-shift at the register worm and by a positive brake applied to the disengaged dial-gear train. Gear-shifting is simultaneous with contact opening and contact closing. Contacts are 25 amps., quick-make and quick-break. (40-amp. rating on special order.) A Telechron motor operates the contact-tripping and gear-shifting mechanism through a direct gear drive. The 24-hour time-dial permits several ON and several OFF time settings, made through a sealed-plug hole in center of glass meter cover without disturbing meter-cover seal.—*General Electric Co., Schenectady, N. Y.*

Illuminated-field Magnifier

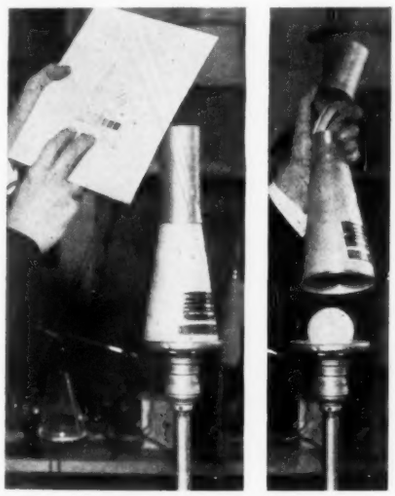
Employs a double-lens system giving 5× magnification in a 2″ field. Bakelite spacer ring holds lenses in proper focus. Field is illuminated by bulb so p'aced in handle that direct light does not reach eye of observer. "Flash-O-Lens" is avail-



able in two models: with battery handle, or for connection to electric source. White composition frame reflects light; an opening in this frame permits use of a pencil or manipulator.—*E. W. Pike & Co., Box 38, Elizabeth, N. J.*

Mercury Vapor Detector

One part of mercury vapor in 10^8 parts of air by volume can be detected and registered by a new device employing selenium monosulphide, a light yellowish compound which the vapor darkens. Previously available SeS equipment required a skilled operator. The new device consists of an aluminum cone, about 4″ diam. at bottom, containing a



holder for a strip of SeS paper. This cone is fitted to a heavy-duty lampholder, with a socket for a 25-watt red Mazda bulb. (A red lamp is used to avoid coloration of paper by actinic rays.) Lampholder has a ½″ S.P.T. so that mounting can be arranged for floor or table stand or wall bracket. Heat from the red lamp causes a fairly constant upward flow of warmed air so that the apparatus may be calibrated to show the concentration of mercury vapor in a room. Color scale provided with the equipment (see left-hand view) has six uniformly graduated colors. Chemically treated paper is supplied in strips ⅞″ wide and 62″ long, wound on spools and in air- and light-tight containers.—*General Electric Co., Schenectady, N. Y.*

Pre-recording Oscillograph

For studies of effects of lightning on transmission lines, etc., recording oscillographs had been developed with shorter and shorter reaction-times, down to $<1^{-6}$ sec., but investigators described their ideal as a device possessing a negative reaction-time: an oscillographic camera which would open its shutter approx. 0.02 sec. *before* the occurrence of the transient under study and close it approx. 0.02 sec. after such occurrence.

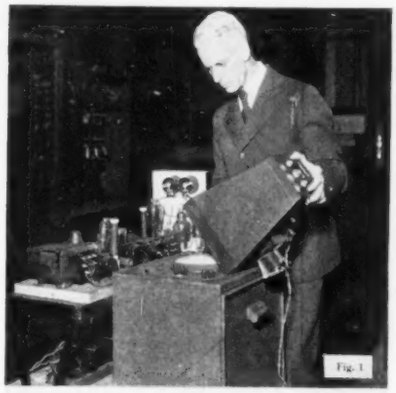
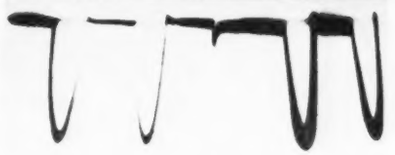


Fig. 1



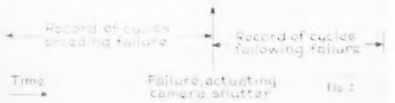


Fig. 2

Although this ideal, in the pre-cognitive form thus described, still seems impossible of realization, an oscillograph (Fig. 1) which gives the same result has been developed by Dr. A. W. Hull. Its cathode-ray tube has a willemite screen with a 0.04 sec. period of phosphorescence; the occurrence of a transient causes a photograph to be taken 0.02 sec. afterward; the result (Fig. 2) is a record covering a total duration of approx. 0.04 sec. with the transient centered.—*General Electric Co., Schenectady, N. Y.*

Photoelectric Illumination Control

This new unit uses an emissive type photoelectric cell; and ordinary radio tubes are used to amplify the changes in current produced by the photoelectric cell. The unit will operate on intensities >0.05 foot-candle. It is recommended by makers for controlling aircraft safety lights on radio towers and high buildings adjacent to airports, beside being suitable in tool rooms, design departments, and schools to insure proper illumination at the point of work. The unit operates from 110-volt a-c. supply and the relay has contact capacity of 500 watts non-inductive load.—*Electronic Control Corp. 2832 E. Grand Blvd., Detroit, Mich.*

Let us quote you on complete

METALLIC BELLOWS

assemblies

Hydron metallic bellows are used as control elements in temperature and pressure control devices, and for liquid or gas seals on compressors and pumps. They are formed from one-piece, thin wall, metal tubing of the highest grade, expressly developed for this purpose.

The bellows have exceptional life characteristics due to the automatic testing of the tube wall in our original patented hydraulic forming process, and to the freedom from rubbing of frictional tool engagement with the thin metal wall during the formative operation.

Increasing numbers of manufacturers find it more economical and more satisfactory to have us supply the complete bellows assemblies. We have the equipment and they are pleased with the results. Let us quote you on complete bellows assemblies for your products.

We are primarily manufacturers of bellows and bellows assemblies rather than completed devices incorporating same, with the obvious intent of avoiding any competitive situation between ourselves and our customers. We do, however, produce to our customers' specifications complete devices involving our bellows.

Write for our catalogue

HYDRON

CLIFFORD MFG. CO.

564 East First Street Boston, Mass.

FACTORY REPRESENTATIVES

Riley Engineering Corp., 1481 14th St., Detroit
Franklin G. Slagel, 923 East 3rd St., Los Angeles
J. J. Shriver, 221 North La Salle St., Chicago

PHOTOELECTRIC RELAYS

No. 5351-D

A complete new line of photoelectric equipment comprising almost one hundred variations in cases, circuits, voltages, sensitivities, secondary circuit capacities, etc. Also, a full complement of auxiliary equipment. Write for detailed bulletin.

PORTABLE, TAUT SUSPENSION GALVANOMETERS

No. 2562

Exceptional values are represented in the new G-M line of portable, taut suspension galvanometers. Pointer types, mirror types, and types comprising only movement housing and magnet for incorporating in testing instruments. The No. 2562 galvanometers illustrated above range in price from $14.25 to $15.75 for sensitivities from 1.25 to 0.125 microamps. per mm. division on scale. Write for Bulletin C. S. 586.

G-M LABORATORIES INC.

1732 Belmont Ave. Chicago, U.S.A.

Write for new complete catalog of Electrical Apparatus for Scientific and Industrial use—available April 15th.

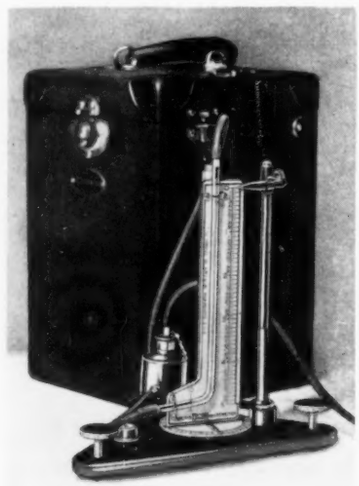
Photoelectric Colorimeter

For determining degree of concentration from color and turbidity of solutions contained in standard glass cuvettes. Regular cuvettes are of 100-cc. capacity;

micro-cuvettes can be supplied in capacities >0.2 cc. Comparison principle is employed: there is one light-source, illuminating two photocells through geometrically and dimensionally similar systems of filters and cuvettes. Bridge circuit including both photocells permits balancing independently of intensity of light-source; employment of a shutter permits calibrating for 100% absorption; and employment of an iris diaphragm permits adjusting sensitivity range. Indicating instrument has both percentage and logarithmic scales. Optional equipment is a sodium-vapor lamp for determinations where monochromatic illumination is preferred. Instrument is said to be the latest design of Dr. Lange (Germany).—*Pfaltz & Bauer, Inc., 300 Pearl St., New York City.*

Micromanometer

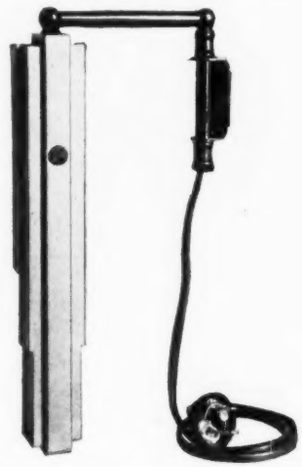
Reading directly to 0.001" water column (0.0001" by estimation), this new instrument is a true micrometric manometer in that it employs (1) the null meth-



od of balancing forces and (2) a uniform-pitch screw and divided circle for measuring the height of the column which balances the measured pressure. Instead of reading a variable level, user raises reservoir to bring meniscus to zero mark. This mark is on lower portion of glass tube, which is inclined to afford maximal sensitivity. Fluctuating pressures cannot be measured. Total range is 0-5" water column. Case measures 11"x 7"x7"; total weight 7½ lbs.—*Teltru Div. of Air Conditioning Engineers, Inc., 121 N. Clark St., Chicago, Ill*

The "Windowstat"

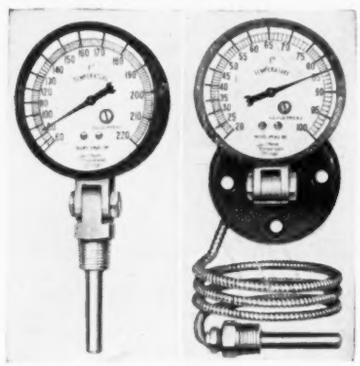
Said to provide complete protection against window condensation during cold outdoor weather, this new instrument has two main applications: (1) To limit



action of humidifiers, so that relative humidity is maintained just below window condensation point. While instrument has no connections to the outdoors, it responds to outdoor temperature, windage, exposure, etc., in their relation to indoor temperature and humidity conditions. (2) To start and stop fans that blow over windows, strip heaters placed below windows, etc., as a means of removing condensation. The instrument works with equal efficiency day and night and needs no attention, it is said, beyond initial installation and adjustment.—*Julien P. Friez & Sons, Inc., Baltimore, Md.*

Dial Thermometers

The Marsh Universal Socket Dial Thermometer has been brought out in two forms: "Type 61" self-contained instrument may be used as a vertical con-



nection thermometer, a 90° back angle thermometer, a front angle thermometer or any intermediate angle. "Type 62" distant-reading thermometer is standard with 6 ft. of connecting tubing and a union bulb or a flexible plain bulb. Mounting flange and universal socket permit installing instrument proper at any convenient point. Either type may be had in ranges between —20°F. and 800°F., either F. or C. graduations. 3½" dial size only; various finishes. Bulbs for various application.—*Jas. P. Marsh Corp., 2073 Southport Ave., Chicago, Ill.*

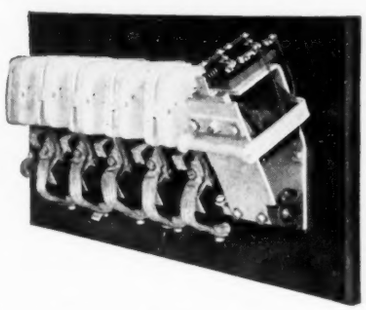
Dielectric Tester

Indicates shorts, opens, or grounds and checks circuits at approved standard testing voltages. Manufacturer states that this new unit is different in that it

permits application of double the rated voltage plus 1000 to the equipment under test. A 6-ft. primary cord is plugged into a 110-volt, 60 cycle outlet. Secondary connections are 4 ft. high-voltage leads ending in test prongs. Secondary test voltage is manually controlled by a tap-switch that provides 500, 1000, 1250, 1500, 1750, 2000, or 2500 volts. Short circuit current is 1 amp. at 500 volts and 0.2 amp. at 2500 volts. The 100% leakage type transformer used in this device "permits short circuit for a period of time without any damage." A second secondary winding on the same common core, but shielded from the high-voltage secondary supplies 110 volts to a ruby lamp, thus warning operator of live secondary leads. On partial breakdown the lamp dims and on complete breakdown goes out.—*Acme Electric & Mfg. Co., 125 Church St., New York City.*

Low-voltage A-c. Contactor

Its design said to be unique, a new low-voltage alternating-current contactor stays closed through voltage disturbances or failure. Instead of utilizing a mechan-



ical latching mechanism, the new contactor is closed by a d-c. magnet energized through a copper-oxide rectifier, and is held closed by the attraction of a permanently magnetized core, and the movable armature. The permanent magnet is made of the new alloy, "Alnico." A reversal of the coil-exciting current, by means of a push button or pilot control device, causes the contactor to open by momentarily bucking down the flux of the permanent magnet. The new device is said to be free from the usual transformer hum experienced in a-c contactors, and to have no coil losses while closed.—*General Electric Co., Schenectady, N. Y.*

High-output Photocells

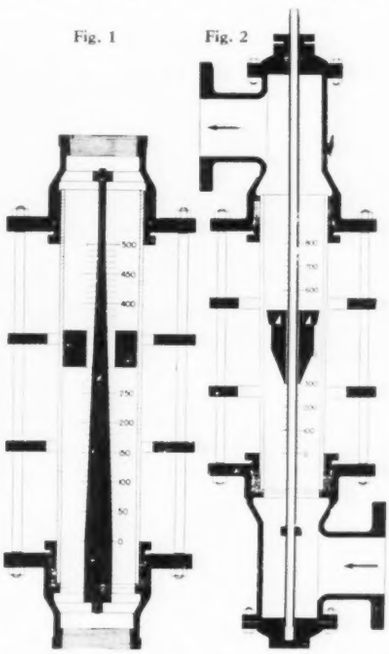
Various photometric and colorimetric measurements can be facilitated and made more precise, it is said, by using a new line of photocells (designed by Dr.

B. Lange of the Kaiser Wilhelm Institute) brought out in several standardized forms. Of the blocking-layer class, these elements have a spectral sensitivity curve close to that of the normal human eye, with maximum at 5750 A.U., and their electrical characteristics (*e.g.*, 400 microamps./lumen) are such as to permit operation of relays and use of commercial microammeters. Illustration shows three forms of these new units: at left a large multi-element unit used for illumination measurements (with the instrument shown); in right-center a smaller illuminometric unit; at right an "ocular" unit with Schott color filters for use with microscopes, spectrometers, etc.—*Pfaltz & Bauer, Inc., 300 Pearl St., New York City.*

Two New "Rotameters"

Principle, characteristics and various forms of "Rotameter" flow-rate indicators have been reported here since their introduction (see *Instruments*, Aug. 1932,

Fig. 1 Fig. 2



page 202; Dec. 1933, pages 222 & 225; April 1935, page 107; May 1935, page 136; Oct. 1935, page 281). Fig. 1 shows a new form for oils and other semi-opaque liquids, which has a tapered axial rod and cylindrical glass so that the indicating rotor can be seen through the thin film of liquid. Fig. 2 shows a new model for liquids which must be kept above room temperature, featuring an axial heating tube through which steam or hot water can be circulated.—*Schutte & Koerting Co., 12th & Thompson Sts., Philadelphia, Pa.*

"AUTOSYN"

Self-Synchronizing Motor

TYPE 769B
ACTUAL SIZE

Type 769B, the smallest self-synchronizing motor manufactured, is suitable for a wide variety of remote indication applications. Slight movements of sensitive elements such as diaphragms and Bourdon tubes may be instantly and accurately transmitted to duplicate or triplicate indicators.

Size—2⅜" diameter x 2⅜" long
Weight—10 ounces
Current—.16 amperes
Voltage—32V. A.C.—60 cycle
Power consumption—2 Watts
Heat Rise—15°C.
Peak Torque—40 Gram. Cm.
Maximum lag — approximately 1½ Degrees
Shaft Diameter—1/16"
Ball Bearing Equipped

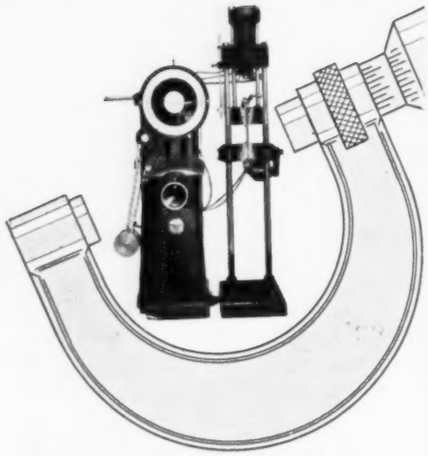
PIONEER INSTRUMENTS

Pioneer Instrument Company, Incorporated

BROOKLYN, NEW YORK

Subsidiary of the Bendix Aviation Corporation

ONE TEST IS WORTH A THOUSAND EXPERT OPINIONS



PRECISION

Every part of a Riehle testing machine is built to Riehle's recognized standards of workmanship. Manufacturing is controlled . . . within close tolerances. Operations are gauged . . . with exacting accuracy. Precision is dominant.

It is the spirit of true craftsmanship which, for more than a century, has enabled Riehle to build better testing machines —of unusual accuracy and dependability, and which give you genuine satisfaction.

RIEHLE DIVISION

AMERICAN MACHINE AND METALS MANUFACTURING CORP.

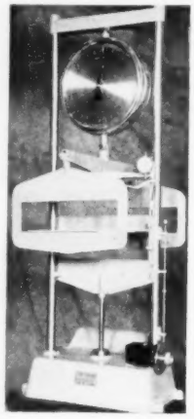
100 Sixth Ave., New York

East Moline, Illinois

RIEHLE DIVISION

Shingle Testing Machine

Shingles may now be tested in transverse for deflection and breaking point under controlled loads <300 lbs. and on adjustable centers <24" by means of this new machine. Load is applied by a small motor-driven nut which draws down the middle crosshead. Motor control is by a knurled knob, and a load may be maintained by stopping the motor at any desired point. The larger dial registers the load: its hand remains at the maximum point at breakage. Deflection is registered on the smaller dial, reading to 0.01". A limit stop at each end of the stroke automatically cuts off the motor. Welded steel construction is used in the transverse supports. The machine is approx. 4 ft. high and weighs approx. 200 lbs.—*Baldwin-Southwark Corp., Philadelphia, Pa.*



Adjustable-mode Control Valve Operators

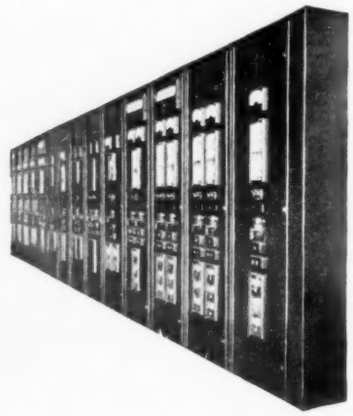
Two new control units are announced, both designed for positive operation of valves under command of a primary measuring element equipped with a slide-wire and responding to temperature, humidity, pressure, flow, level, etc., both externally alike, both developing a 75-lb. pull at end of operating lever, both having a 4" max. stroke and a 60-sec. period for full stroke, and both operating on 110-volt a.c., but each giving a distinct mode of control: (1) The "Relatrol" gives the control mode commonly described by the statement that "the valve is tied to the temperature." (2) The "Balancer" adds thereto an automatic shifting of the mid-point (and hence of the entire "swing" or group of valve positions) to compensate for large and continued changes in the process demand. These units can be used in conjunction with many standard pyrometers, flow meters, etc., by slightly modifying the contact mechanism. In certain instances the required instrument changes can be made in the field. For manual remote control, a hand-operated index and dial replaces the measuring instrument. Overall dimensions, including operating lever, 9½"x9"x6¾".—*Automatic Temperature Control Co., 34 East Logan St., Philadelphia, Pa.*

Redesigned Air Circuit Breaker

"Type AF-1" air circuit breaker, designed for control and protection of industrial circuits, house service entrance, etc., has been redesigned to provide a "mid-position" of the handle, between the "on" and "off" positions, to indicate automatic tripping even when the breaker is enclosed in a case. Reclosing is accomplished by moving the handle to the extreme "off" position: breaker is then ready for closing. Other new features are a mechanical "pry" to open the contacts when manually operated and (in the double- and triple-pole units) a latch that is more resistant to shocks. Appearances and dimensions are unchanged. New design is available for 230-volt a-c., 125/250-volt d-c., 50-amp. use.—*General Electric Co., Schenectady, N. Y.*

"Streamlined" Switchboards

With instruments recessed so that they project about 1", a new construction is being applied to vertical switchboards, benchboards, cubicle doors, metal-clad front enclosures, and swinging brackets. Air circuit breakers used are of the dead-front type, with the current-carrying parts enclosed. Other devices have been redesigned for semi-flush mounting, so that the new switchboards have a modern appearance harmonizing with smooth walls, clean floors, and machines of modern design.—*General Electric Co., Schenectady, N. Y.*



Surface Thermostat

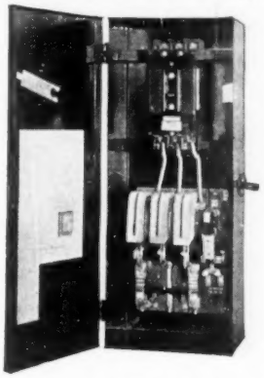
Designed for mounting on flat surfaces such as heating plates, tanks, etc., and rated at 1000 watts 110- or 220-volt a-c., this bimetallic type thermostat measures 4½" x 1¾" x 1¼". Upper range limit is 550°F. and differential is 5°F. Adjustment is by knob on top, features being that its shaft is insulated from live parts and that it is clamped to prevent turning due to vibrations. Thermostat may be used on d.c. by connecting a capacitor across terminals.—*George Ulanet Co., 85 Columbia St., Newark, N. J.*

Oval-back Thermometers

Several improvements in design and construction are said to make these new instruments suitable for the laboratory as well as the plant. Case is one-piece solid copper or aluminum-finished steel, including finger-hold **A** and bulb-guard **E**, which are usually soldered on the stamped back. Patented "Capstan head" **B** holds lens-front tube in proper relation to auxiliary metal scale **D** so securely as to prevent slippage. This scale is etched on the metal of the frame. Principal feature, however, is that a primary scale **C** is etched on the lens-front tubing itself, permitting precise readings in addition to the easy readings afforded by auxiliary scale D. Mercury thermometers are available in four stock Fahr. ranges:—30-130, 20-220, 20-300, 20-460; spirit thermometers in the first two. All are 10½" long and can be used interchangeably in the new oval-back case or in three other styles of cases.—*H-B Instrument Co., 2518 N. Broad St., Philadelphia, Pa.*

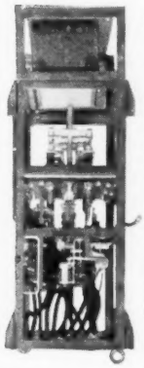
Combination Magnetic Switches

A new line of combination magnetic switches, with maximum ratings of 25 h-p. at 220 volts and 50 h-p. at 440 volts to 600 volts, parallels but does not supersede



maker's similar-ratings line of magnetic switches combined with overload relays for motor-running protection. In these new switches, air circuit breakers which can be reset by hand after tripping are used instead of fused safety switches. Breaker operating handle interlocks with enclosing case door so that it cannot be opened when breaker is closed, and breaker can be locked either open or closed from the outside of case.—*General Electric Co., Schenectady, N. Y.*

High-voltage A-c. Contactor



Employing the oil-blast principle of arc interruption and intended for use in completely oil-immersed motor controllers requiring moderately high interrupting capacity, a new high-voltage alternating-current contactor is rated 200 amp. at 2,200 to 4,600 volts, and will interrupt 50,000 kva. It is latched in, and is tripped mechanically on short circuit by an instantaneous over-current relay. Thermal-induction relays give inverse-time protection for the motor in the event of sustained overloads, and time-delay undervoltage protection also is provided.—*General Electric Co., Schenectady, N. Y.*

Draft Controllers

For small and medium-size forced-draft stoker-fired boilers and natural- or forced-draft oil-fired boilers, a new line of small square-form furnace-draft con-

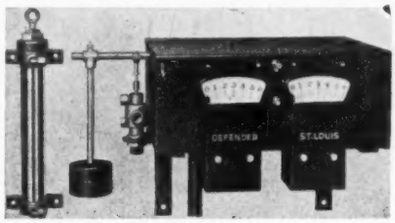


Fig. 1

trollers comprises right- and left-hand patterns to reduce installation costs, improve appearance and promote efficient utilization. Controllers are supplied with both draft and wind-box gages as shown in Fig. 1, or with only one gage, or without any gage. Operating principle (see Fig. 2) consists in having float 5 actuate

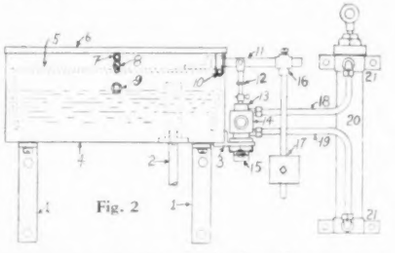
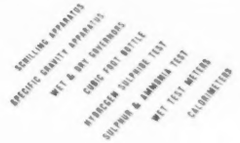


Fig. 2

pilot valve 14 whereby hydraulic pressure (city water supply) is transmitted by either of copper tubings 18 or 19 to power cylinder 20 which operates damper. Setting is readily adjusted by shifting counterweight assembly 16-17 on lever 11. Dimensions: bell casing 13"x 10½"x5"; overall length 18".—*Defend r Automatic Regulator Co., St. Louis, Mo.*

Measuring Pump

Available in four sizes, for standard pint, quart and gallon containers (with which it is regularly supplied complete) this new device, the "Presto Automatic Measuring Pump," facilitates dispensing small quantities of oils, glycerine, etc. It delivers 0.5 oz. (1.0 oz. in largest size) with each full stroke of the plunger. It is double-acting. It may be supplied also to fit special containers used in various industries.—*V. R. Hall Products Co., 9304 Amesbury Ave., Cleveland, Ohio.*

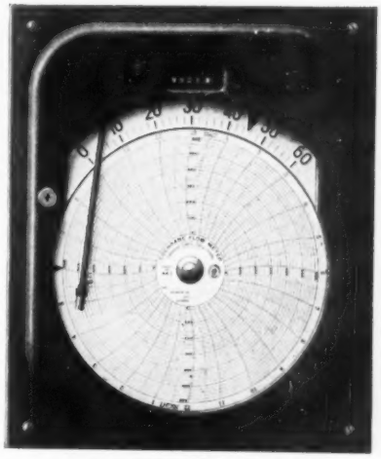


• • • For your convenience they are all included in this one handy new bulletin! Complete catalog data with specifications on each type.

It brings together in one catalog the line of laboratory gas testing apparatus available from American Meter Company including many improvements in these standard instruments. Catalog AG-1 will be mailed to you on request.

AMERICAN METER COMPANY
INCORPORATED
Measurement and control of Gas, Oil, Steam, Air and Liquids
ESTABLISHED 1836
GENERAL OFFICES: 60 E. 42ND ST., NEW YORK, N. Y.

321



COCHRANE FLOW METERS

INDICATING
RECORDING
INTEGRATING

COCHRANE FLOW METERS insure against wastage and provide a basis of facts for properly governing operations. The recorders of Cochrane Flow Meters—both the electric and mechanical models—are guaranteed accurate within one-half of one per cent of absolute, at full load.

Cochrane Electric Flow Meters use the galvanometer null principle, universally acknowledged as the most accurate means for measuring a force or quantity. These meters are ideal for central panel installations.

Write for complete information

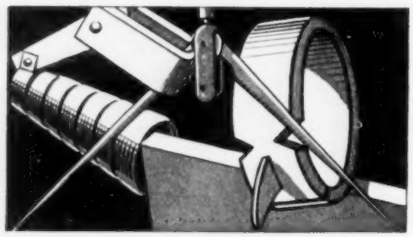
COCHRANE CORPORATION
Dept. INS
Allegheny Ave. and 17th St., Philadelphia, Pa.

Do you know your vacuum?

Let the TRU-VAC gauge tell you—accurately—continuously. Records pressures from 0—10,000 microns. Invaluable in processes requiring dependable knowledge of vacuum conditions.

Its numerous advantages are outlined in our bulletin TV2, gladly sent upon request.

CONTINENTAL ELECTRIC CO.
St. Charles 6, Illinois
PHOTOCELLS VACUUM SWITCHES



TRUFLEX BIMETAL is The Handy Man in Instrument Control

Truflex is "Jack of all Trades"—*and master at every one.* Truflex bimetal coils compensate for local temperature conditions in indicating and controlling pyrometers. Truflex strips serve as time-delay devices for intermittent current control and as circuit-breakers for overheat protection. In many other instruments you'll find Truflex adding precision and safety to temperature control.

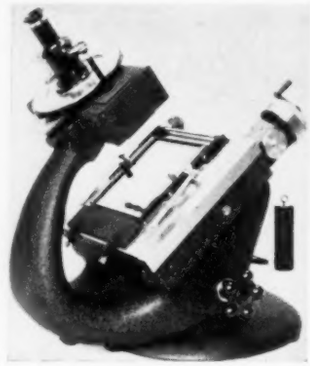
Truflex is a permanently fused laminated metal. It bends quickly when temperature changes. It is precision rolled, consistently uniform, and low in cost.

A bulletin shows how economically Truflex control can be built into your product. Send for it. No obligation.

GENERAL PLATE CO.
ATTLEBORO, MASS., U. S. A.

Film Reading Comparator

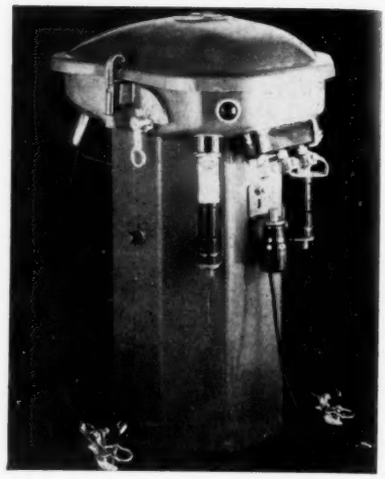
This coördinate comparator with motion of 2"x4" is intended for measuring points on a film or for measuring the angle between a line on the film with



another reference line, as in interpretation of photographic records of reference points in vector systems. Consists essentially of two slides in parallel planes and with motions at right angles to each other. Reading microscope fitted in the upper slide magnifies 4×, is supplied with 90° cross-hairs, is mounted in a 3½" circle fitted with a vernier and magnifying glass to read to 0.1°. Upper micrometer has a range of 2". Measurements can be made to 0.001". Lower slide and stage has a motion of 4". Stage position can be read to 0.001". Stage has an opening 5"x 3½" with clear glass plate on which are engraved two perpendicular lines as references for motion of slides. A guide, two metal spring clips and a glass plate on a hinge with a spring, are provided to facilitate locating and holding film in relation to reference lines. A mirror is adjustably mounted on base to give illumination through glass slide. Entire unit is mounted on a heavy circular base on which it can be adjustably tilted and clamped for convenient observation.—*Gaertner Scientific Corp., 1201 Wrightwood Ave., Chicago, Ill.*

Completely Self-protecting Transformers

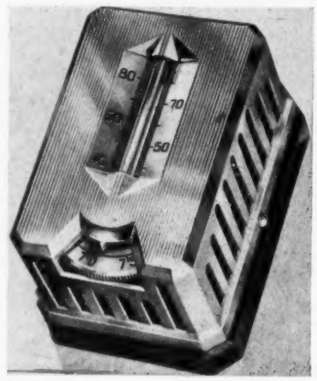
Completely self-protecting distribution transformers that withstand lightning, prevent burnouts from short circuits or overload, and have links in the primary winding to protect against feeder outage in the event of internal winding fault are announced in standard voltage classes from 2400 to 13,800 volts, 1½ to 50 kva, 60 cycle, single phase. Universally applicable on any distribution feeder, either delta connected or 4-wire grounded neutral. No fused cutouts are used. Secondaries are normally arranged for 3-wire service, but may be reconnected to give full output on 2-wire service. Designed, built, and installed as a unit. Require no separately mounted protective devices. Special "De-ion" gaps discharge not only ordinary surges but also surges associated with direct strokes of lightning. Thermal elements of breaker are submerged in transformer oil so that breaker responds both to current flow and to oil temperature. "TR" breaker assures complete thermal protection and permits transformer to carry higher overloads (permissible at lower ambient temperatures) which occur in winter when ambient temperatures are lowest—



an exclusive feature. When winding temperature reaches a predetermined value (approx. 100°C.) bimetal element flashes a red bull's eye; breaker itself tripping out at a higher temperature. This load-indicating scheme gives customer an opportunity to replace transformer by a larger one at a convenient time and avoid a service interruption at a critical time.—*Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.*

Room Thermostats

A full line of room thermostats is announced, the units incorporating several new features, among which are dead-front and concealed contacts for protec-



tion against dust. New line comprises thermostats for 250-volt service as well as for 125 and low voltage (30 and less). Three types: standard, heat-accelerator, and outside compensated cooling control unit. In addition to regular wall mounting, there are available mounting accessories for special outlet box, conduit connection wall plate for over-the-surface mounting and standard switch box with plain or switch plate. This switch plate is a transfer switch for changing the thermostat from winter heating to summer cooling control or vice versa. In the new models greater sensitivity is given to the corrugated "Klixon" disks by giving complete freedom for air flow through the case. Manufacturer claims also that the corrugated "Klixon" disks have nearly absolute precision of repetition, a small differential and more power per unit of mass and per unit change of temperature.—*Spencer Thermostat Co., 34 Forest St., Attleboro, Mass.*

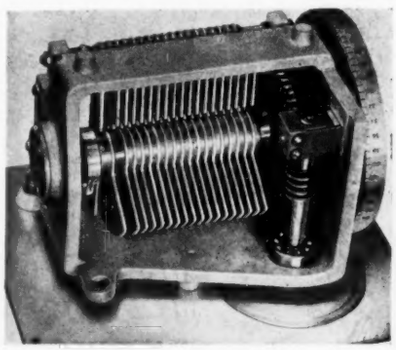
Direct-reading Electronic Audio-frequency Meter

Designed for production and testing work where many measurements must be quickly made, but suitable also for precision laboratory work, new "Type 834-A" audio-frequency meter reads di-

rectly from 0 to 200, 500, 1000, 2000 and 5000 cycles—the desired range being selected by a multiplier switch—and operates directly from a-c. supply. Amplifier circuit permits accurate measurements over signal voltages from <3 to 200 volts.—*General Radio Co., 30 State St., Cambridge, Mass.*

Precision Capacitors

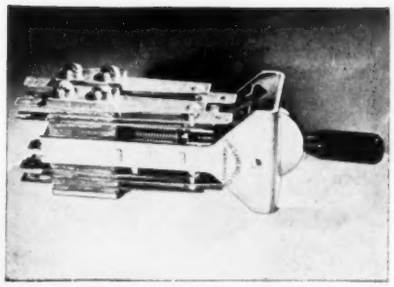
Availability of new materials and methods of construction have enabled manufacturer to replace "Type 222 Precision Condenser" with this completely re-designed "Type 722" in which all error



sources have been practically eliminated. Entire assembly is mounted in rigid Al-Cu alloy frame which has practically same temperature coefficient of expansion as $\frac{3}{8}$" thick aluminum plates, resulting in a 0.002% temperature coefficient of capacitance. Mechanical design and construction represent close approach to perfection, as does arrangement whereby both drum dial and disk dial are read from a single window in panel. Figure of merit $R \omega C^2 < 0.04 \times 10^{-12}$ at 1 kc. At 1 Mc the inductance is 0.06 μ h and metallic resistance 0.024 Ω. Two sizes are available: "722-H" with maximum capacitance of 1400 $\mu\mu$ f and 0.06 $\mu\mu$ f precision of setting, and "722-F" with a 500 $\mu\mu$ f maximum and 0.002 $\mu\mu$ f precision. Each may be had mounted or unmounted.—*General Radio Co., 30 State St., Cambridge, Mass.*

Cam Lever Switch

Designed for use in circuits where break-down requirements do not exceed 2500 volts. Contacts are rated at 1 amp., 110 volts d.c. non-inductive load. Overall dimensions of type shown are 2½" wide, 5½" long from handle to end of contacts and 1¼" thick. A positive stop is provided in center position so that when handle is returned to this position from



an operated position, contacts on opposite side of switch are not affected. There is approx. 1/16" between rollers and operating springs when switch is on center position. The springs are a complete assembly and may be removed from frame without changing settings of springs or contacts. Contact springs are tinned phosphor bronze. Stop springs are provided for all but operating springs. Operating spring contacts have flat surfaces; contacts on all other springs are rounded: formed from ¼" silver rod and firmly set in place as they are formed. Various spring and contact combinations are available.—*The Gamewell Co., Newton, Mass.*

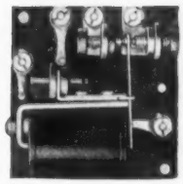
Spectrum Measuring Microscope

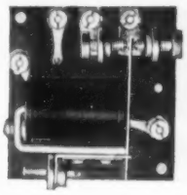
Designed for rapid and precise measurement of the linear intervals between spectrum lines on photographic plates but applicable to determinations of

shrinkage and expansion of photographic films in aerial mapping, thermal expansion of metals, elongation of test specimens in creep tests under load, etc. Plate or other object to be measured is carried upon a sliding table to which is rigidly attached a glass scale 250 mm. long, read by transmitted light. Magnified image of scale and vernier is projected by a microscope objective upon a horizontal ground glass screen underneath eyepiece of reading microscope. For measuring spectrum lines there is added to the observing microscope, behind the objective, a small slide carrying interchangeable spherical and cylindrical lenses. When the cylinder is in position and adjusted so that its axis is perpendicular to the spectrum line, the images of the individual silver grains are drawn out into overlapping lines giving the image a smooth appearance in which all evidence of grain is absent. The spherical lens, which interchanges with the cylinder, serves to keep the system parfocal.—*Bausch & Lomb Optical Co., Rochester, N. Y.*

KURMAN OFFERS

2 New D. C. Sensitive Relays


2C


1C

SENSITIVE
14 Milliwatts for positive operation.

ADJUSTABLE
Pull up—drop out—speed.

DROP OUT
From 50 to 85% of pull.

CONTACTS
Fine silver—1½ amps 110 V. A.C.

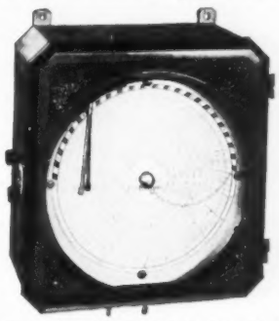
RANGE
.0005 V. 25 amps -to- 20 V. .00065 amps.

FEATURES
1C—Wide contact separation.
2C—Speed .001 seconds.

RUGGED
Some customers report 4 years continuous satisfactory operation.

Kurman Electric Co., Inc.
241 Lafayette Street, New York City

What the modern temperature recorder is to the common thermometer
—So is the new HAYS
PYCNOGRAPH
(SPECIFIC GRAVITY RECORDER)
to the common hydrometer.



The front portion of the Pycnograph is a square-case round-chart recorder. The rear portion is a continuous-flow gravimeter—as simple and as precise as a chemist's balance—yet ruggedly built of Corrosion-resistant materials (to your specifications if necessary). Working ranges 5° Baumé and up. It is hailed as the solution of many problems.

SEND FOR LITERATURE

In.
Name.....
Company.....
Address.....

THE HAYS CORPORATION
INSTRUMENTS SINCE 1904
MICHIGAN CITY, INDIANA

Just Out

MERCURY ARC RECTIFIER PRACTICE

By F. C. ORCHARD
A.M.I.E.E.

"Written by one who has intimate knowledge of the snags liable to arise in the selection, installation and operation of rectifier plant."—*Electrical Times*

"Excellently adapted to give the modern electrical engineer an adequate working knowledge of this new and important factor in distribution."—*Scottish Electrical Engineer*

"Avoids necessity for laborious work in searching for and wading through publications . . . Essentially a practical man's book."—*The Engineer*

"Should be very useful to the plant engineer and operator, and should enable him to consider a rectifier layout more intelligently and to carry on maintenance and overcome troubles more efficiently." — DR. JOSEPH SLEPIAN in *Instruments*

$5.00 postpaid

Instruments Publishing Co.
1117 Wolfendale St. ❖ Pittsburgh, Pa.

PYRO THE SIMPLIFIED OPTICAL PYROMETER

SELF - CONTAINED, DIRECT READING, RUGGED AND FOOL-PROOF

Unique construction enables operator to rapidly determine temperature even on minute spots, fast moving objects, or smallest streams; no correction charts —no accessories. PYRO OPTICAL is now available in a new type with three separate, direct-reading scales—ideal for steel mill, open hearths, soaking pits, laboratories, etc.

Stock Ranges: 1400° to 5500° F.

PYRO RADIATION PYROMETER

Ideal for furnace or kiln use. Gives actual heat of material aside from furnace or kiln temperature. Does not require a skilled operator, — strictly automatic. Eliminates personal errors. Always ready to tell within three seconds any shortcomings in your equipment. Stock ranges 1000° to 3600° F.

Write for special bulletins

THE PYROMETER INSTRUMENT CO.
103-107 LAFAYETTE ST., NEW YORK, N. Y.
GRANT BLDG., PITTSBURGH, PA.

Autographic Color Analyzer

First displayed at the recent convention of the A.A.A.S., a recording photoelectric spectrophotometer facilitates analyses of the reflected or transmitted color of a wide variety of materials. The sample is placed in the instrument, operation is started, and in <3 min. the operator removes a chart on which the spectral distribution curve between 4000 and 7000 A.U. has been drawn automatically (see Fig. 1). The instrument consists essentially of a monochromator, photoelectric photometer, and means of recording their respective indications. The monochromator, of the double-dispersion prism type, is equipped with bilateral slits which are adjusted automatically for a 100-A.U. band. The photometer combines the polarizing method of photometry with a photoelectric balancing scheme. Reflectance values are expressed in percent of the standard selected by the operator. Transmission values are expressed either directly in percent or in terms of a standard transmission sample. The recorder is of the drum type, with wavelength value related to the drum position and photometric value to pen travel. *Principle*: Light from an incandescent lamp is passed through a hollow-U-tube, through a series of slits, prisms and mirrors. At the other end of the tube is a hollow sphere. The light reaching this sphere has been split into two polarized beams, each of the same wavelength and, in the course of an analysis, covering the spectral range. One of these beams strikes the standard—usually a piece of "pure white" magnesium carbonate—and the other the sample under investigation. If the analysis is for reflected light, both the standard and sample are affixed to the sphere. Before entering the sphere the light beam passes through a rochon prism mounted in the hollow shaft of a high-speed synchronous motor. The rotation of this element serves to vary the light intensity of the incident beams from minimum to maximum on the sample and standard out of phase with each other. A phototube views a frosted glass in the wall of the integrating sphere, the brightness of which is a function of the sum of the product of beam intensity and reflectance for both sample and standard. When the light reflected from the standard is unequal to that reflected from the sample, an a-c. component is present in the phototube current, its phase with respect to the voltage applied to the synchronous motor determining which of the two reflected beams is the more intense. This amplified alternating component is then used to control the direction of rotation of the balance motor by an amplifying tube stage which readjusts another rochon prism to obtain a redistribution of energy in the sample and standard beams, thus removing the alternating component in the phototube current. The angular position of the last-mentioned rochon prism is then a measure of the reflectance of the sample in terms of the standard. Transmission measurements are made by using a sample and standard of the same material—again usually $MgCO_3$—and introducing the transmission specimen in the incident sample beam. Provisions are provided also for placing a standard transmission specimen in the standard beam. The light incident on the sample and standard is derived from one source, eliminating the characteristic of the light source in the measurement. The optical system with respect to the standard and sample is common, with the exception of one pair of decentered lenses, used to obtain wider angular deviation of the sample and standard beams. Since the voltage amplifier and amplifying tube stage amplify alike the current due to light from sample and standard, the measurement is independent of the characteristics of these units. Since only monochromatic light reaches the phototube, the spectral response characteristic of the phototube does not enter into the result.—*General Electric Co., Schenectady, N. Y.*

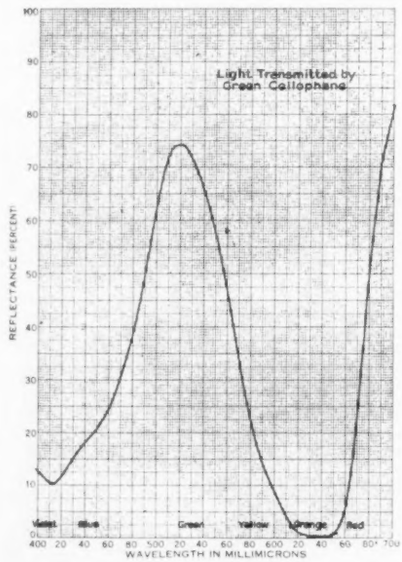


Fig. 1

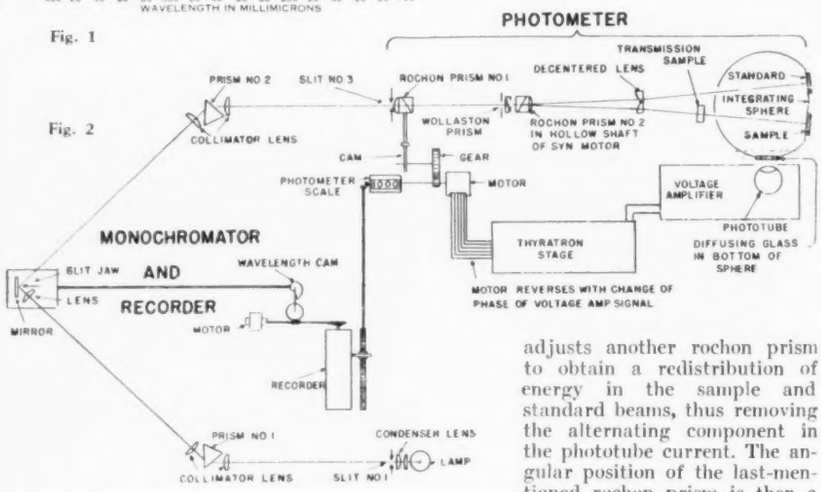


Fig. 2

Transmission Line Fault Location

New Method Utilizing High-frequency — Effect of Resistance in Fault

By J. E. ALLEN

Chief of Tests, Pennsylvania Water and Power Company

INTRODUCTION

A METHOD of locating mechanical failures on overhead transmission lines such as those caused by wet snow and sleet has been developed by the Pennsylvania Water and Power Co. for use on twelve 70-kv. circuits which radiate from the Holtwood power house. The following advantages have been realized: (1) less than one-half hour is requried to report a fault location, (2) determination of fault is not dependent upon the kind of fault, (3) no communication with patrolmen is needed and (4) 2% accuracy can be obtained.

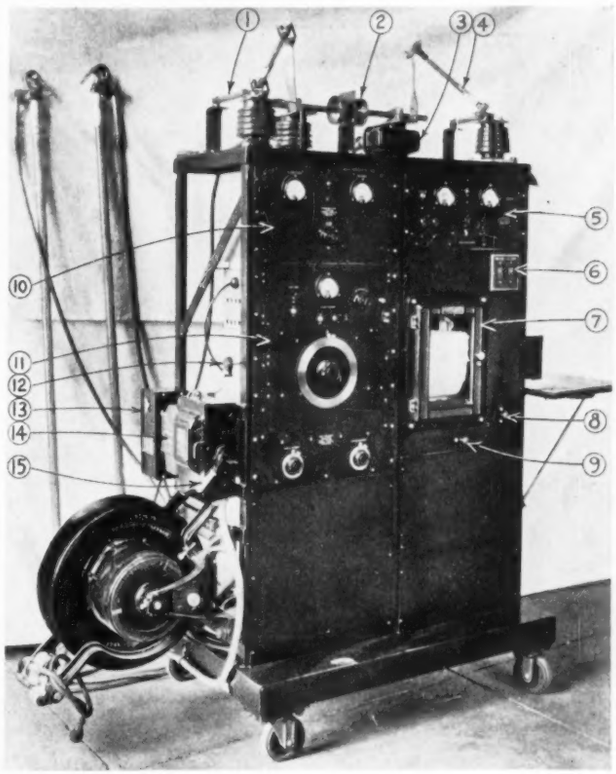


Fig. 1. Fault locating equipment. 1. 7000-ohm drain resistor; 2. 4" sphere gap; 3. Chapman arrester; 4. 10 amp., 25,000 volt fuse; 5. D-c. power supply panel; 6. Motor & clutch switches; 7. Recording milliammeter; 8. Manual clutch control; 9. Output short-circuit switch; 10. Amplifier panel; 11. Oscillator panel; 12. Manual frequency control; 13. Low voltage arrester; 14. 220/110 volt transformer; 15. Safety switch.

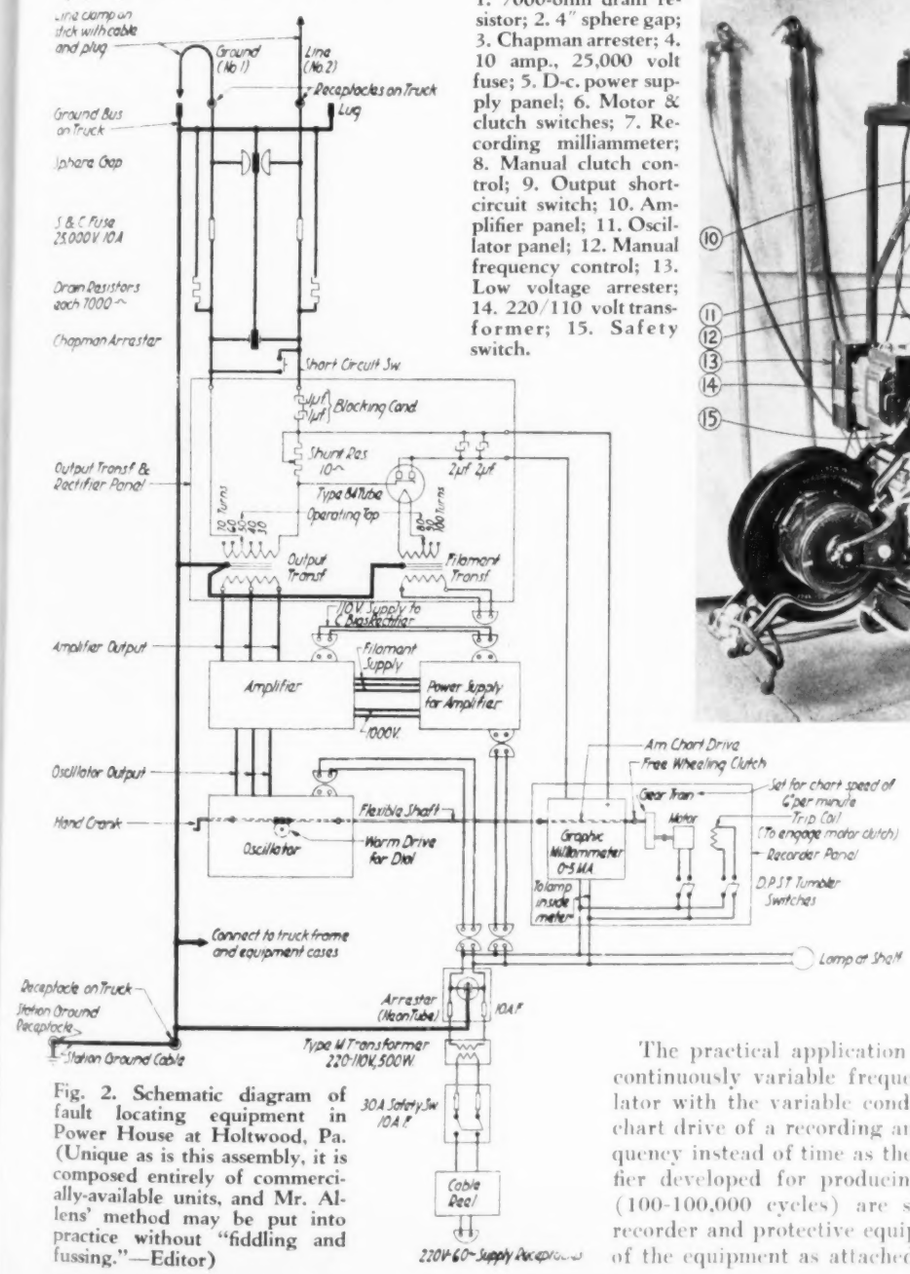


Fig. 2. Schematic diagram of fault locating equipment in Power House at Holtwood, Pa. (Unique as is this assembly, it is composed entirely of commercially-available units, and Mr. Allens' method may be put into practice without "fiddling and fussing."—Editor)

PRINCIPLE OF METHOD

The method involves the use of high frequency in a manner which may be described briefly as follows: When a continuously increasing source of frequency is impressed between a transmission line conductor and ground, a series of current peaks will result having regular repetition or constant frequency difference between successive peaks. This frequency difference is inversely proportional to the length of the line and thus affords a means of determining the length of the line or distance to the fault. The relationship is given in the following formula:

$$L = V/2d$$

where L = distance in miles to fault, d = average difference in frequency between successive current peaks, and V = velocity of propagation in miles per second.

The practical application of this method requires a source of continuously variable frequency such as a beat frequency oscillator with the variable condenser mechanically connected to the chart drive of a recording ammeter to produce a record with frequency instead of time as the abscissae. The oscillator and amplifier developed for producing the source of variable frequency (100-100,000 cycles) are shown in Fig. 1 together with the recorder and protective equipment. Fig. 2 is a schematic diagram of the equipment as attached to a circuit.

The routine procedure involved in making a fault determination on a three-phase circuit consists in obtaining three frequency-current peak charts with the test equipment connected between a conductor and ground and with the other two idle conductors solidly grounded at the testing station. The far end of the circuit may be either grounded or ungrounded as desired. The frequency of the first and last current peak is obtained from a calibrated frequency scale laid on the chart and the difference in frequency divided by the number of "valleys" between the current peaks chosen thereby securing an average difference d which is substituted in the above formula to obtain the distance to the fault.

CURRENT PEAK DISTORTION AND FAULT RESISTANCE

Under certain conditions the current peaks secured in the above manner may be somewhat distorted. The causes contributing to the phenomenon of distortion will be discussed, as well as the effect of resistance in a fault—which has a relation to the phenomenon of distortion. While it is believed that both distortion and resistance are of no concern in practice, nevertheless it is felt that the technical principles involved are of sufficient interest to justify publication of the following discussion relating thereto, so that interested companies may use the method to the fullest advantage. In general, the cause of distortion has been found to be due to the amount of resistance in the fault. However, resistance is not always a source of distortion and the following explanation is given in order to distinguish between two characteristic conditions.

THEORY UNDERLYING DISTORTION

The phenomenon of recurring current peaks is due to phase shift and reflection on a conductor having distributed capacitance and inductance. An ideal case is one in which the reflection at the fault is 100%. When this condition exists, the current peaks are (1) without distortion, (2) evenly spaced, and (3) of uniform amplitude over the full frequency range. When 100% reflection does not take place it is due to the presence of resistance in the fault. The effect of this resistance depends upon how it is located with respect to the conductor. In case the resistance is between the conductor and ground (the only case of interest in practice) the effect when the resistance is at the far end of the conductor is altogether different from the effect when the resistance is somewhere along the conductor. These two basic conditions are illustrated in Figs. 3 and 4.

In the first case, Fig. 3, the resistance R influences only the amplitude of the current peaks. When the resistance is zero the reflection is 100% and the amplitude is a maximum and equal to the same amplitude as when the resistance is infinite (open circuit). As the resistance is gradually increased the amount of reflection diminishes, resulting in current peaks of smaller and smaller amplitude until they disappear completely—a condition which occurs when the value of resistance is equal to the surge impedance of the line, or approximately 400 ohms. At this value there is complete absorption and no reflection. However, as the resistance is further increased above 400 ohms, partial reflection begins to take place resulting in a reappearance of the current peaks until full amplitude is reached at infinite resistance, when the reflection is 100%.

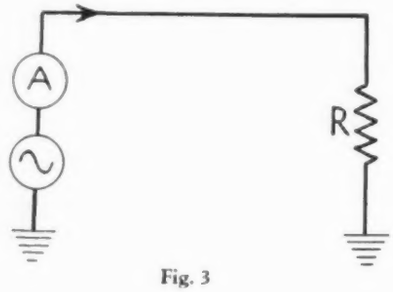


Fig. 3

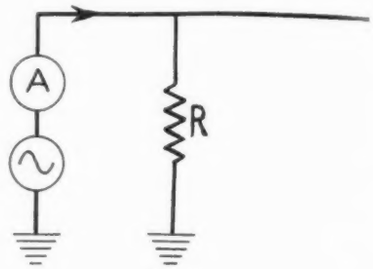


Fig. 4

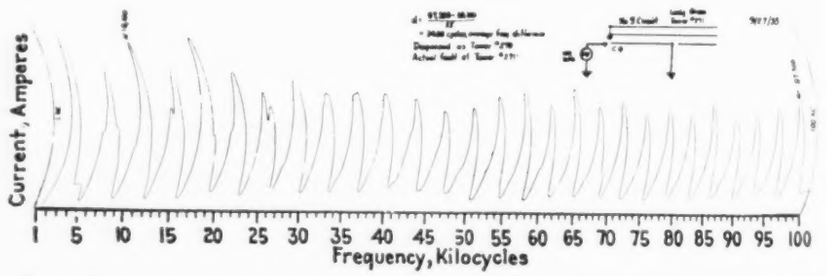


Fig. 5. Frequency - current peak chart taken on 40-mile, 70-kv. steel tower transmission lines with overhead ground wires. Conductor broken and end solidly grounded to tower 26.3 miles from testing end.

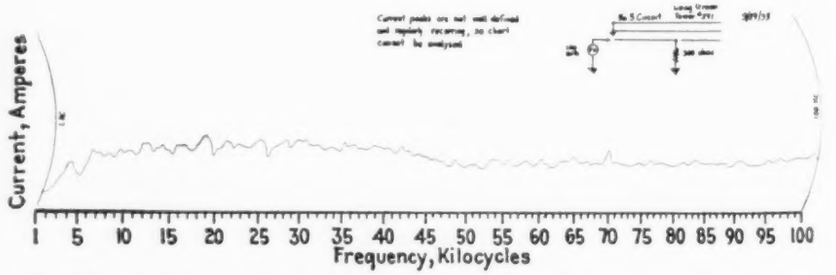


Fig. 6. Frequency - current peak chart taken on 40-mile, 70-kv. steel tower transmission line with overhead ground wires. Conductor broken and end grounded to tower through 300 ohms non-inductive resistance 26.3 miles from testing end.

In the second case, Fig. 4, the reflection at the resistance R is a continuously diminishing amount as the value of the resistance increases, there being no value at which there is complete absorption such as at 400 ohms in Fig. 3. Consequently, the current peaks resulting from the reflection at R will decrease in magnitude as the resistance at R is increased. Since the reflection at R is not complete except at zero resistance, there is some high-frequency voltage existing at R which will travel to the far end of the line where it will be reflected back to the sending end, creating another series of current peaks. These will combine with those originating at R, producing resultant peaks having distortion, variation

in amplitude, "beats," etc., depending upon the distance to the fault and the value of resistance. Reflections from the far end may be avoided by terminating the line in 400 ohms non-inductive resistance which will completely absorb the high frequency. By means of such termination, faults of the type in Fig. 4 can be located.

CHARACTERISTIC TYPES OF CHARTS

The foregoing explanation of the effect of resistance in a fault for the two cases in Figs. 3 and 4 serves as a basis for interpretation of charts. Accordingly, it can be stated that when a chart is secured with peaks of large and uniform amplitude and with little distortion, the conductor fault is of the type shown in Fig. 3, in which R is either zero or infinite (open circuit). See Fig. 5. In practice this means either that the conductor is without a fault or that it is broken; with the end on the sending side either grounded to a low resistance or not touching either tower or earth.

When the amplitude of the peaks is relatively small but uniform and with little distortion, the end of the conductor on the sending side is terminated in a resistance to earth either higher or lower than the surge impedance of the line. When the peaks are so small that they cannot be distinguished in regular repetition the conductor is terminated in a resistance exactly equal to its surge impedance (see Fig. 6). This value is rather critical, *i.e.*, a value of approximately 50 ohms higher or lower than the surge impedance will increase the peaks so that they may be used for fault location (see Fig. 7).

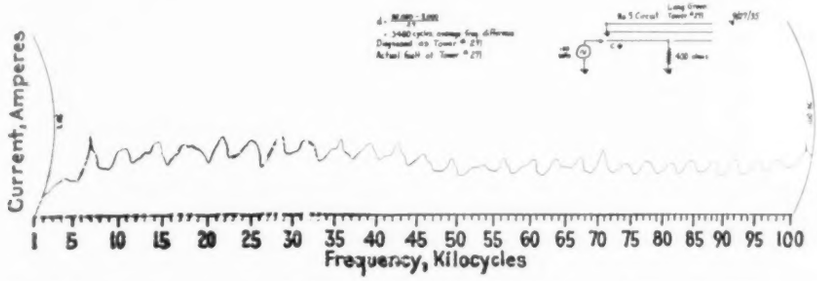


Fig. 7. Frequency - current peak chart taken on 40-mile, 70-kv. steel tower transmission line with overhead ground wires. Conductor broken and end grounded to tower through 400 ohms non-inductive resistance 26.3 miles from testing end.

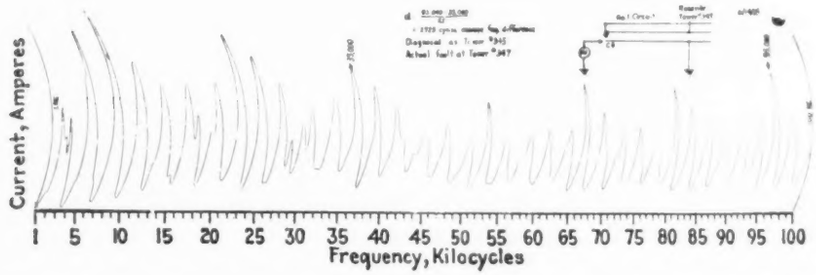


Fig. 8. Frequency - current peak chart taken on 40-mile, 70-kv. steel tower transmission line with overhead ground wire. Conductor solidly grounded to steel tower 33.7 miles from testing end.

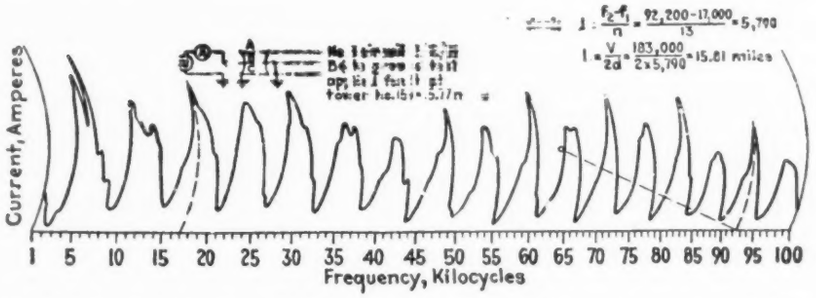


Fig. 9. Frequency - current peak chart taken on 40-mile, 70-kv. steel tower transmission line with overhead ground wires. Artificially applied fault consisting of a between-wire short on A and C phases (without a ground) and a ground on B phase at the same tower. Fault 15.8 miles from testing end.

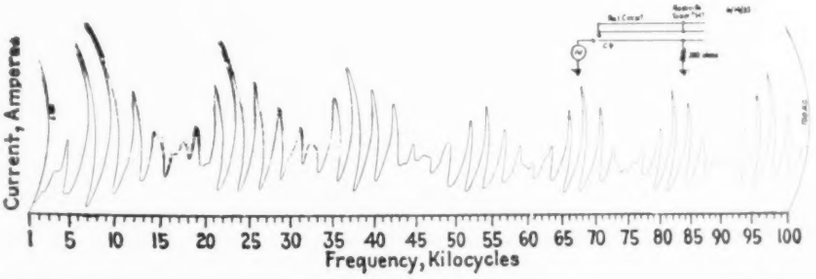


Fig. 10. Frequency - current peak chart taken on 40-mile, 70-kv. steel tower transmission line with overhead ground wire. Conductor grounded to steel tower through 200 ohms non-inductive resistance 33.7 miles from testing end.

The actual value of surge impedance has been found to vary between 300 and 500 ohms, depending upon the condition of the idle phases. In practice, a high resistance would result from a broken conductor either lying on the earth or making contact with a steel tower without overhead ground wire, but the probability of the value being exactly equal to the surge impedance or within ± 50 ohms is rather remote.

The other type of fault, Fig. 4, is the one which is the chief cause of distortion of current peaks due to small ripples or reflections from the full length of the line. Even when a conductor is solidly grounded to a tower having an overhead ground wire, the resistance of the ground return is sufficient to create noticeable distortion such as the appearance of small ripples on different parts of successive peaks, flattened tops, etc. (see Figs. 8 and 9). Such distortion is not serious and it may be ignored because the fundamental portion of a peak may easily be identified. In fact, tests have shown that the resistance may become as high as 100 ohms without distorting the peaks so seriously that they can not be used.

The "beat" effect is a result of the phenomenon of partial reflection in which the current peaks from the high resistance fault combine with the current peaks from the end of the line, producing resultant current peaks varying in amplitude and having an envelope with a certain periodicity depending upon the distance to the fault. However, the envelope of the current peaks should never be used to determine distance to the fault. When a frequency chart shows

a "beat" effect and the individual peaks by analysis show a distance equal to the full length of the line, it is obvious that a high-resistance fault exists, and the line must be terminated in its surge impedance to locate the distance to the fault. An example of such termination is shown in Figs. 10 and 11, the fault resistance being 200 ohms. However, charts having a "beat" effect may be safely used when the individual peaks show regular repetition and by analysis show the distance to the fault less than the full length of the line.

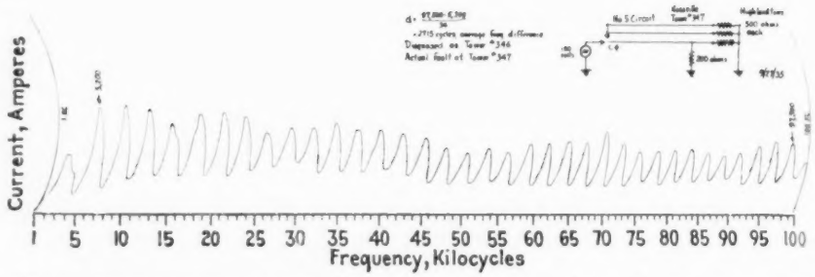


Fig. 11. Frequency - current peak chart taken on 40-mile, 70-kv. steel tower transmission line with overhead ground wires. Conductor grounded to steel tower through 200 ohms non-inductive resistance and each phase of far end of circuit terminated in 500 ohms non-inductive resistance. Fault 33.7 miles from testing end.

REFERENCE

Other examples of frequency charts illustrative of the two characteristic types of faults are given in the August, 1935, *Bulletin* of the Edison Electric Institute. Certain features of the method are also covered in more detail, such as apparatus, routine procedure, and fundamental characteristics of current peaks.

INSTRUMENTS' BOOK SHELF

Fluorescence Analysis in Ultra-Violet Light. By J. A. Radley and Julius Grant. D. Van Nostrand Co., New York, 1935. Cloth, 5½x8¾ inches, 326 pages. Price $7.00.

This book fills an increasing need for a reliable summary of the applications of fluorescence under ultra-violet light for testing and analytical purposes. The reader cannot help being impressed with the number and variety of such applications.

In the first part of the book, the construction and operation of different kinds of ultra-violet lamps are described. The use of suitable filters is discussed and in the chapter on methods and technique of analysis the working conditions of standardized methods are explained. All this information is of utmost importance for obtaining the best results.

The greater part of the book contains nineteen chapters of practical applications of fluorescence analysis in the different fields of use such as for the examination of foods and drugs for adulterations; for the detection of forgeries and alterations of documents in legal and criminological examinations; for the examination of minerals and ores, etc. Each chapter describes in some detail the most important applications. At the end of each chapter are given complete references to original articles which are of inestimable value to the investigator who needs greater detail than is possible in the descriptive matter of the book. Everyone working with fluorescence produced by ultra-violet light will find much of real interest and help in this book. H. C. Rentschler (7.8)-B-

Relay Systems. I. T. Monseth and P. H. Robinson. McGraw-Hill Book Co., New York, 1935. Cloth, 6x9 inches, 549 pages, 452 illustrations. Price $6.00.

The authors of this book, representing respectively a large manufacturer and an extensive public utility, have given us an authoritative text and reference manual of circuit and apparatus protection. With the exception of the "Relay Handbook" this may be said to be the first comprehensive presentation of American relaying practice. Any misunderstanding as to the somewhat ambiguous title is removed in the first chapter, where it is made apparent that the work deals solely with *protective* relays and their applications. This chapter outlines the various types of system trouble against which protection must be provided, together with the bearing of the predominating type of load upon the class of protection needed.

Six chapters are devoted to an analysis of fault calculations, both balanced and unbalanced, the latter being treated by the fundamental system of symmetrical components. Much attention is given to the predetermination of the nature and magnitude of current and voltage conditions attendant upon various types of faults. With a view to the use of the book by students and teachers, as well as by practicing engineers, there are presented numerous examples involving problems which might be encountered under actual operating conditions.

Emphasis is placed upon the distinction between requirements of instrument transformers for protection and for metering; and, by a consideration of underlying theories, it is made clear where transformers can, and where they cannot, be used in common for the two purposes. A thorough treatment of the use of differential schemes in the protection of apparatus occupies a chapter of 60 pages. In the discussion of line protection there appears a complete analysis of the characteristics of available types of relays and the utilization of these characteristics in a great variety of arrangements suited to different distribution systems. The use and limitations of pilot systems, both of the carrier current and separate pilot-wire types, is discussed in full, including a treatment of the coördination of such methods with communication lines.

The application of high-speed relays to prevent loss of synchronism is based on recent studies of system stability. A number of highly specialized relays for this type of protection are described in detail, and their use given a thorough treatment from both a theoretical and a practical basis. An interesting and particularly valuable chapter deals with the subject of wave-form phenomena, showing the effect of wave distortion on relay performance, and including a discussion of the distorting effects of abnormal conditions, both transient and sustained, on current transformers, and a comprehensive treatment of precautions to be observed in the provision of proper wave-forms during checks and calibrations. The book closes with a chapter on the testing and maintenance of relays.

The volume is liberally illustrated with line drawings and diagrams, and bibliographical references are sprinkled through its pages. While the most complex systems and conditions are thoroughly covered from every standpoint, the approach is at the same time simple and direct. Teachers and students, as well as designing and operating engineers, will find that reference to this book will eliminate the expenditure of a vast amount of time on uncharted research.

Perry A. Borden (13.2)-B-

MORE BOOK REVIEWS
ON PAGES
76 81 87 88 89

Your Invention—How to Protect and Merchandize It. By Elmore B. Lyford. Radio & Technical Publishing Co., New York, 1935. Cloth, 5½x8½ inches, 206 pages. Price $1.50.

"Hereafter," declared the reviewer's wife, "I will hide this invention book when we have friends for dinner and bridge, so that the first man to arrive will not bury himself in it and ruin the evening! Do you realize that *every* man who picked it up had to be torn from it?" We *had* noticed it; we noticed also that among those men were not only young engineers but the Director of Research of a large industry, the head of a section in the Bureau of Standards, and other well-read men of long experience.

Yes, that is the kind of a book Mr. Lyford has written—a really "fascinating" book—and his own preface is rather modest: "The author has attempted to present, in practical form and everyday language, those essentials with which every person having anything to do with patents, trademarks or copyrights should know . . . help bridge the gap . . . between the conception of an idea and the successful exploitation of the patented object or process. The author has no interest in any patent or trademark promotion. He has no patent advice or services to sell, nor has this volume been written for any purposes of exploitation whatsoever."

Part 1 (nine chapters) explains how patents are procured; Part 2 (six chapters) outlines the essentials of successful exploitation and frankly discusses banks, wealthy friends, etc.; Part 3 deals with trademarks; Part 4 deals with copyrights; Part 5 gives twenty-four suggested legal forms, and Part 6 contains selected extracts from the U. S. patent laws.

We recommend this book unreservedly. But don't let your bridge guests see it! M. F. Béhar (12)-B-

Fault Location Correction Methods

By C. E. CLUTTS

Transmission Development Dep't, Bell Telephone Laboratories, New York

AT first glance the task of locating within a few feet a small and perhaps invisible fault in a section of toll cable several hundred thousand feet long would seem extremely difficult, especially if one appreciates the variety of conditions encountered which might lead to errors. However, with the testing equipment and correction methods now available, insulation troubles and open conductors can be located in most cases within plus or minus one hundred feet. Thus cablemen, when directed to a certain calculated location, will have only a short section of cable to inspect.

The responsibility for locating these faults accurately usually rests with the attendant at the primary toll test board.* On receiving notification that a particular circuit is in trouble he determines the nature of the fault by means of a voltmeter; after that he proceeds to locate the position of the fault by making Wheatstone bridge measurements and introducing the values obtained into the proper formulas. A cableman is then dispatched to the point of trouble as quickly as possible to make repairs, to keep the trouble from spreading to other pairs and to reduce lost circuit time to a minimum.

Before toll cables came into extensive use the outside toll telephone plant consisted largely of open-wire lines which for the most part were located along highways, and the need for highly accurate fault locating measurements was not great since wire troubles were in general readily visible. In addition the wires were easily accessible and check tests could be made when necessary. As the telephone and telegraph facilities demanded from a given open-wire plant increased, however, it became important to reduce the time necessary to locate and clear cases of trouble.

With further growth, long toll cables containing large numbers of circuits have in many sections supplanted open-wire lines. In such cables all joints are permanently sealed so that in general there are no places outside the telephone offices where metallic contact can be made with the wires without opening the cable sheath. Moreover, every cable sheath opening adds considerably to the cost of trouble clearing. The introduction of toll cables has also involved the use of a much larger percentage of private right-of-way to which access may be difficult, and it is accordingly important to direct cablemen making repairs to the location of the trouble as accurately as possible.

Thus, with the introduction of toll cable it became necessary to locate faults within a hundred feet instead of a mile or two—an increase in accuracy in the order of one hundred to one. To achieve this refinement, improvements have been made in two directions. The development of more accurate and sensitive Wheatstone bridges has resulted in improvements in the accuracy of fault locating measurements. In addition, a further gain has been realized by analyzing fault locating methods and formulas and providing correction methods for calculations which may be in error because of irregularities in the cable conductors.

Formulas used in the location of faults by means of electrical measurements are based on the physical fact that certain electrical characteristics of a conductor are proportional to its length, but conditions which satisfy this relation are seldom realized in practice. In addition to such irregularities as those caused by loading coils, lumped capacitance, etc., the wires in the outer layers of a cable are longer than those near the center because the layers of wire are spiralled. In non-transposed cables this irregularity is balanced out by the large number of random splices in a fifty-mile cable section, but correction must be made in the case of transposed cable in which a single splice near the center of a cable serves to connect the wires in the outer layers on one side of the splice to wires in the inner layers on the other side. This is because the apparent distance along the cable sheath to a fault will vary, considerably, depending on whether the fault is located in an inner or outer group of conductors.

Fig. 1 shows a correction curve which can be used for transposed cable, in which case the inner and outer layer pairs are spliced together near the middle of the cable section. In an average section of fifty miles this splice would be about twenty-five miles from the cable terminals. Measurements of average inner and outer layer pairs show a normal difference of about one ohm per mile. The error caused by such a difference is a maximum at the transposition splice and decreases to zero at both ends of the line. Corrections can be made either by calculation or from a curve which forms part of the cable records.

Temperature variations have a marked influence on the resistance of wire and cause changes not only from

*A. J. Pascarella. Locating Faults on Toll Lines. *Bell Laboratories Record*, Vol. 7, Dec. 1928, pages 161-164.

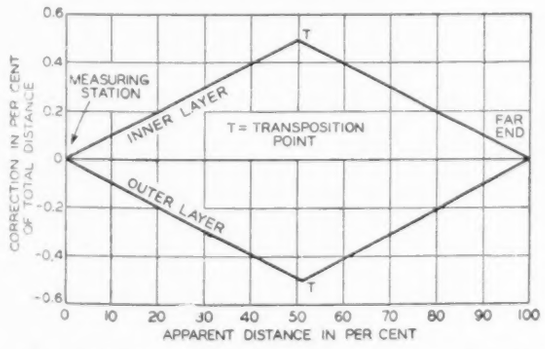


Fig. 1. The inner and outer layers of a transposed cable being interchanged at only one point, near the middle of the section, the correction for the apparent distance to a fault then becomes a maximum at this point.

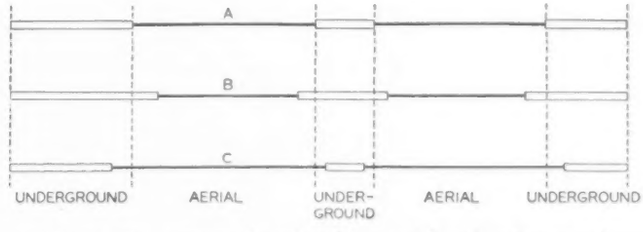


Fig. 2. The apparent lengths of the aerial and underground sections of a cable, as determined by resistance measurements, varies with the temperature of the different sections. If A represents the actual lengths, B and C show apparent lengths when the underground sections are at higher or lower temperatures respectively than the aerial sections.

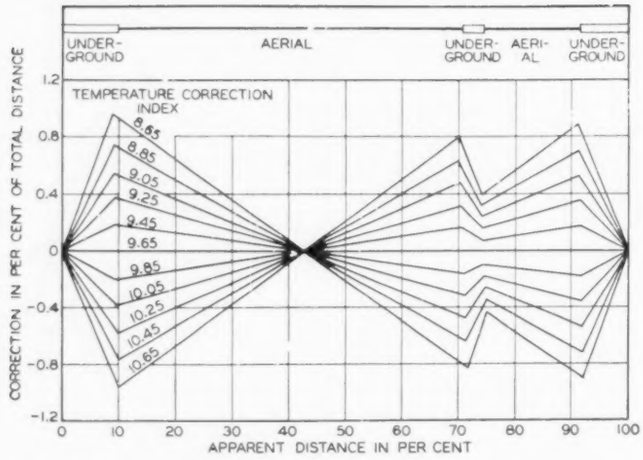


Fig. 3. Insulation faults are located by making resistance measurements on the cable. The apparent location has to be corrected by an amount which depends on the relative temperatures of the aerial and underground sections.

season to season but from hour to hour. Thus, when sunshine is followed by a sudden downpour of rain a material change in conductor resistance may take place within a few minutes. This condition becomes complicated where some of the sections of a cable are aerial and some underground, because the aerial sections are subject to rapid temperature changes whereas the underground portions change relatively slowly. Under these circumstances what is known as an underground temperature correction is required. To determine this correction it is not necessary to know the true temperatures of either the aerial or underground sections or the actual difference between them, but merely the ratio of resistance of an underground section to the resistance of the entire cable pair containing the underground section. This ratio, or temperature correction index as it is called, is determined for each fault at the time that the regular loop and Varley measurements* are made. Taking the general case of a cable with one intermediate and two terminal underground sections the actual lengths of the aerial and underground sections may be as shown at A in Fig. 2. If, when making Wheatstone bridge measurements the underground sections are at higher or lower temperatures than the aerial sections, the several parts of the cable will appear to have lengths as shown respectively at B and C in Fig. 2. This difference between actual and apparent lengths will cause an error in the location of a fault. The error will always be the same for a given temperature difference between the aerial and underground sections, however, and consequently corrections can be calculated for the temperature variations which are normally encountered. Such calculations are usually made at the time the cable is installed and become part of the permanent cable records. The corrections are recorded as a family of curves, like that shown in Fig. 3, but with finer graduations. The values in percent of total cable length are given for different temperature conditions in terms of the temperature correction factor which is expressed in percent of the resistance of an underground section to the total resistance of the cable pair. For example, if the apparent distance of the fault is 20.00 percent of the total cable length and the temperature correction factor is 10.25 percent, the correction to be applied to the apparent distance is -0.40 and the corrected distance is $20.00 - 0.40 = 19.60$ percent of the total cable length.

*The Varley measurement gives the resistance of a cable pair between the fault and the distant end of the cable section.

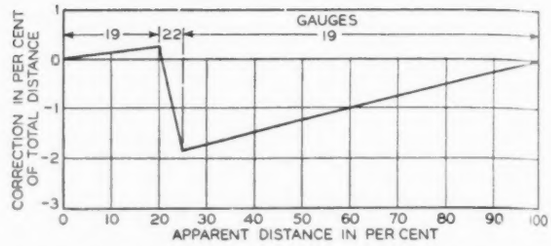


Fig. 4. Where sections of the cable are of different gage, or if sections of different capacitance are used, special correction curves such as this are prepared.

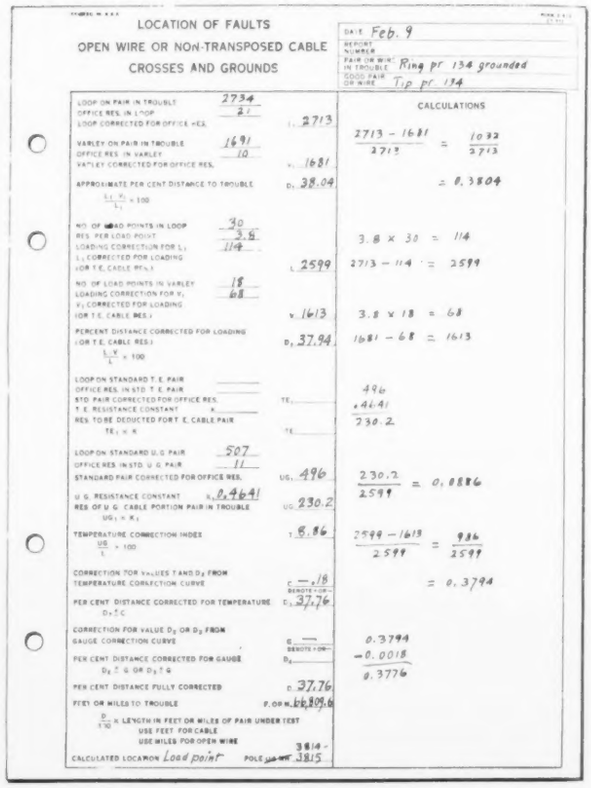

LOCATION OF FAULTS
OPEN WIRE OR NON-TRANSPOSED CABLE
CROSSES AND GROUNDS
DATE Feb. 9
FAIR OR WIRE IN TROUBLE Ring pr. 134 grounded
GOOD FAIR OR WIRE Tip pr. 134
CALCULATIONS
2713 − 1681 / 2713 = 1032 / 2713
= 0.3804
3.8 × 30 = 114
2713 − 114 = 2599
1681 − 68 = 1613
496 + 41.41 = 230.2
230.2 / 2599 = 0.0886
2599 − 1613 / 2599 = 986 / 2599
= 0.3794
0.3794 − 0.0018 = 0.3776
CALCULATED LOCATION Load point
POLE 3814 - 3815

Fig. 5. Standard work sheet, with calculations for a typical case.

Lump capacitance such as that due to condensers or building-out cables can best be treated by simply subtracting these constants from the fault locating measurements as necessary, depending on the apparent location of the fault with respect to the added capacitance. Where sections of different gage or of different capacitance are involved, correction can be made more easily by the use of correction curves of the type shown on Fig. 4. These curves are constructed for particular sections of line and form part of the permanent records of the testing section.

Work sheets as well as correction curves are provided with the object of securing the greatest possible speed in the location of faults consistent with accuracy. A standardized form is thus attained (Fig. 5) and the tester is thereby relieved of the need to consider the order of procedure.

The use of the above correction methods has resulted in a substantial decrease in the average fault locating error which is now about one hundred feet in the toll cable plant. This has reduced the time required to locate faults with consequent gain in efficiency of operation and decrease in maintenance costs.

Make Testing Serve, Not Retard, Production

By G. E. HANN

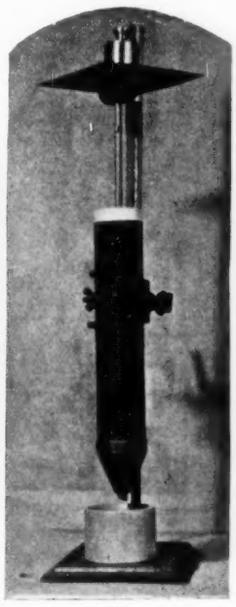
Director of Research, The Tremco Mfg. Co., Cleveland, O.

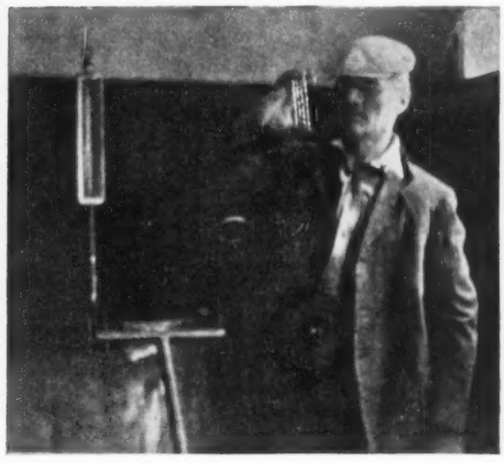
PRODUCTION control tests concern all of us in industry: The more accurate and efficient these tests are, the less grief we have further along in the production line; where quality is important, materials must be checked for possible defects; in every line of manufacture *uniformity* enhances the company's reputation. Instruments being available for determining almost any physical or chemical property of matter in order to assure conformity to the standard batch, instrumental testing is carried on by all progressive companies. The usual procedure is to maintain a completely-equipped and ably-staffed laboratory . . . *and to locate it in an isolated spot.* This article will show the disadvantage of such isolation, suggest a simple remedy, present examples of its application (see the figures) and report results.

There usually is some arrangement to have samples of various batches, or periodical samples from a continuous production system, rushed to the laboratory for approval. It is then necessary to convey this approval to the point of manufacture, either by messenger or telephone. With such a system, even a complete and thorough laboratory can rarely be an *efficient* aid to production. Thoroughness in a variety of operations is not compatible with efficiency. Effective research requires slow but all-encompassing forward motion. Little things cannot be overlooked. It often is found that minute observations develop into the most important part of research. There is no such thing as "speed-up efficiency" in theoretical or even practical research. When a strain is put on research men, they lose consciousness of the value of detail in their type of work.

Lost motion makes it hard for a capable research operator to do efficient production testing. It is impracticable to have the laboratory be at all of the points where it is necessary to have the testing work performed. Conveying the samples to the laboratory, the return of the approval, and other red tape between the man at the machine and the man with authority to give approval—all these instances of lost motion cost money.

Lack of synchronism between the findings from the test and the production itself is another disadvantage. For example, the laboratory sees a gradual inclination toward one end or the other of the allowable limits. Then, when the production man is suddenly told that his batch is not up to standard, he is lost: believing that he has been making the material the same right along, he is unable to appreciate that his gradual inclination has led him so far away from his standard batch. Closer tolerances would not solve this problem: the results would be more rejects and a greater loss of some valuable employee's time. The underlying trouble in this case is that the production man only gets the laboratory's "O.K." or "N.G." He cannot use the results of laboratory tests to feel his way and guide his operations.





LEFT. This factory man has taken a half-pint sample of the material from the finished batch and placed it under the plunger of a standard Penetrometer. Six needles with various sizes of tips from 1/16" to 3/4" have been made so as to fit the plunger of the instrument. He simply allows the plunger to go down through the compound during a specified time, and then reads the distance of its descent by means of the standard gage on the instrument. Since temperatures vary and since we have to allow a certain tolerance, we have two variables. We therefore draw up a graph with two curves and simply give the operator to understand that it must fall between the two lines.

CENTER. Simplified consistency testing apparatus. A smaller gun, that slips inside the black outer shell, is loaded full of caulking from the batch in the mixer to be approved. The operator simply puts the cap on the gun, slips it into the shell which is fastened to a stand. He places the weight on the small metal platform attached to the handle of the gun and allows it to force the compound out of the nozzle into the cup below. The number of inches the metal platform passes in a given time is the consistency figure. With the temperature held fairly constant in production batches, definite values can be posted, between which this figure must come.

RIGHT. Using one of the sealed standards of various viscosities, of which the laboratory has made up a full set. The viscosity tube is marked with the code number of the oil it is to represent. When the varnish maker has come close to the length of time the oil is supposed to run at a definite temperature to give the desired viscosity, he takes a sample, cools it, puts it in an empty tube and watches the speed of rise of the bubbles in the tube in comparison with the standard. When the bubbles in the tube of oil he is making rise at the same speed as those in the adjacent standard tube for that oil, he pulls the batch. When in doubt, he presses a bell-button to summon a chemist.

Hard feelings between the production man and the man responsible for the laboratory approval are due to pressure from opposite directions: the laboratory is responsible for a uniform product of the best quality possible and the production man is responsible for maximum output. Seldom do they really work together. Rush orders, new products, break-downs on production lines—such causes build up pressure on each of the parties from the center.

The entire system of carrying samples to a remote laboratory for approval is comparable to leaving your brain at home and running back there to obtain a decision on whether or not to go, after the traffic light has turned green. The obvious remedy is to put the testing equipment on the job. Thus the brains are taken to the work and coördinated with the fingers that do the job. It has been found that as soon as this is done, production increases naturally; control testing becomes *efficient;* and the quality of the material improves.

The basic reason for these improvements is that the laborer doing the testing thinks of his job through the instruments. He holds to closer limits than if the sample were taken to the laboratory, since he automatically synchronizes the production operation with the results that he obtains from the testing operation. His tests become more delicate as far as the production is concerned, since he recognizes changed results of the testing operation as due to specific changes in production routine. He speeds up arrival at a satisfactory batch. He has respect for the instrument and its job and relies on it as well as do the laboratory men because he understands his connection with the testing routine. He ceases to fight the laboratory's control tests, since he now knows them to be a direct aid to his work. He does not hesitate to call on the laboratory for assistance. When he finds that a control test shows the material not up to standard, he has a certain amount of intuition available with which to track down the cause of the defect.

Moreover, by putting testing instruments to work in the factory and using the production men for the control testing, high-salaried laboratory men are relieved of unnecessary routine work and given more time for fundamentally important work.

In general, the first step in setting up a system of this nature is to determine whether or not it is practicable to do the testing operation on the job. In making this determination it is well to bear in mind that *any testing routine is worthy of a trial on the job.*

The next stage is to simplify the test procedure: reduce it to a series of numbered steps each described without technical terms. Often, too, instruments that are simpler and more rugged than laboratory standards can be obtained when the allowable limits are considered. The operations can be outlined on a large chart placed where it is easily seen during the testing operation.

A survey of the laborers on the production job is made by the chief chemist and the foreman, and the most promising man on each process is instructed carefully in the numbered steps of the simplified test. The method of calculating the results and the tolerances allowed are explained to him. He is made to understand what the test means and why it is important to know that the material is within the allowable tolerances: how business is lost when the product is released outside the allowable tolerances, or even when that particular material varies.

The next stage is to allow the laborer to run the test himself. He is supervised until it is evident that he understands the simplified routine and the tolerances.

If possible, samples of the same material that the laborer tests are labeled and sent to the laboratory; and he is informed that these samples of the material okayed by him are checked there as an extra precaution to insure uniformity. If this idea is put across effectively, there is little danger of the laborer's passing any batch that does not check within the tolerances.

A simple log sheet should be arranged so that his results can be recorded as he tests each batch. These sheets should be preserved carefully and sent to the man in charge of the periodical approval of batches. This is *not* "paper work" in its usual meaning: it *saves* clerical work in addition to saving production and laboratory money.

Such are the essentials of the remedy. Results of its application have shown that testing routines ordinarily considered "unavoidable nuisances" can be used to (1) increase the interest of the employee in his work and (2) increase the uniformity and efficiency of manufacture.

INSTRUMENTS' BOOK SHELF—*Continued from page 72*

Messbrücken und Kompensatoren (Measuring Bridges and Potentiometers), Vol. I. By Dr. Josef Kronert. R. Oldenburg, Berlin, 1935. Linen, 6½x9½ inches, 282 pages. Price 13.80 RM.

The author of this German book states in a prefatory note that his inspiration lay in the need for a single reference work where could be found descriptive matter on the large number of bridge and potentiometer circuits available or in use. The book therefore makes little claim to originality, but is put forth rather as a compilation of existing material from a great number of diverse sources reduced to a common basis of exposition. Incidentally, what was first intended to be more or less of a handbook has grown to the magnitude of two volumes, this being the first to appear, and containing the theoretical groundwork of the various *circuits,* leaving for the second volume descriptions of the physical construction and the operation of the instruments in which these circuits may be embodied.

The book opens with a theoretical discussion of networks, and their analysis according to Kirchoff's laws and Maxwell's cycle, with considerable attention given to the transformation of certain types of networks into equivalent and more readily analyzed circuits. In the introductory chapters direct-current and alternating-current networks are carried along simultaneously, the voltage and current relations in a-c. networks being given great clarity by means of suitable graphs and vector diagrams. The flow of current in networks is fully analyzed by equations, making clear the essential principle of each type of bridge circuit discussed. While the chapters on d-c. bridges might be said to be based on the well-known Wheatstone and Thompson networks, there has been set forth a surprising variety of modifications of these circuits, each suited to its specific purpose, such as resistance measurement, temperature determination, gas analysis, or combustion control. A short section is devoted to the use of vacuum tubes in d-c. bridge networks.

Galvanometers and detectors in general are not treated, but there are shown a number of effective relaying systems by which weak unbalance conditions may be amplified to values readily readable on practical galvanometers. The treatment of d-c. potentiometers, while brief, is comprehensive, and sets forth at least twelve basic circuits.

The section dealing with essentially a-c. bridges and potentiometers opens with a consideration of a-c. detectors and amplifiers, followed by a thorough treatment of the subject of grounding and shielding of a-c. measuring networks and the effects of inductance and capacitance, showing the precautions necessary to be observed in associating these phenomena with balancing circuits. The technique of systematically reducing a-c. networks to a balanced condition is discussed in an interesting and original manner. Diagrams are given showing over 120 types of a-c. bridge circuits, each explained and fully analyzed.

Many sources have been drawn upon for descriptive matter dealing with the a-c. potentiometer in its numerous forms; and its application is shown not only to the determination of alternating voltages, but to such purposes as the determination of transformer characteristics and the measurement of frequency.

Appended to the text of the book is an unusually comprehensive bibliography of approximately 350 references definitely keyed to relevant portions of the text, more than one-third of these references being to articles in British or American publication.

The thoroughness with which Dr. Kronert has handled the subject (*item;* 350 illustrations) is quite in keeping with the best class of German technological literature. The book will prove helpful and inspiring alike to the student, the teacher, and the technician; and if the first volume can be taken as an indication of what may be expected in the second, the author should lose no time in making both sections of the work available, not only to his countrymen but to his English-speaking confreres.

Perry A. Borden (4)-B-

Continued on page 81

Auxiliary Equipment for Cathode-ray Tubes

Ninth part of "The Cathode-ray Oscillograph and Its Applications" being published serially in *Instruments*. This series began in the July 1935 issue.

By RALPH R. BATCHER

Radio engineer; cathode-ray and electronic application specialist, Hollis, L. I., N. Y.

TIME BASE CIRCUITS
(*Continued*)

In the January article of this series the complete circuit diagram of the RCA universal oscillograph was shown and briefly discussed. The linear time base circuit of this equipment will now be referred to. Its feature is that a selected capacitor is charged through a variable resistance (frequency control) and at frequent intervals is allowed to discharge through the gas-filled triode (885). In order to keep the sweep sufficiently linear, this charging process is interrupted while the charge is small in order to keep within the approximately linear portion of the curve. This process relieves the 885 tube from deterioration due to heavy charging currents, and permits the elimination of a tube for the charging resistance. However, the total amplitude which would result from this sweep is inadequate for giving a screen-wide deflection. The output therefore is always connected through an amplifier to increase the deflection. The degree of linearity with such a circuit depends on the care in the design of this stage of amplification.

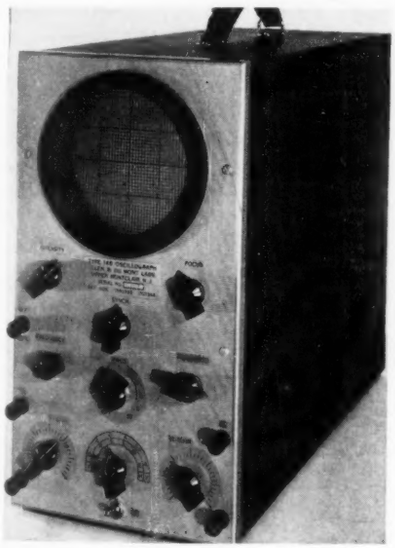


Fig. 23

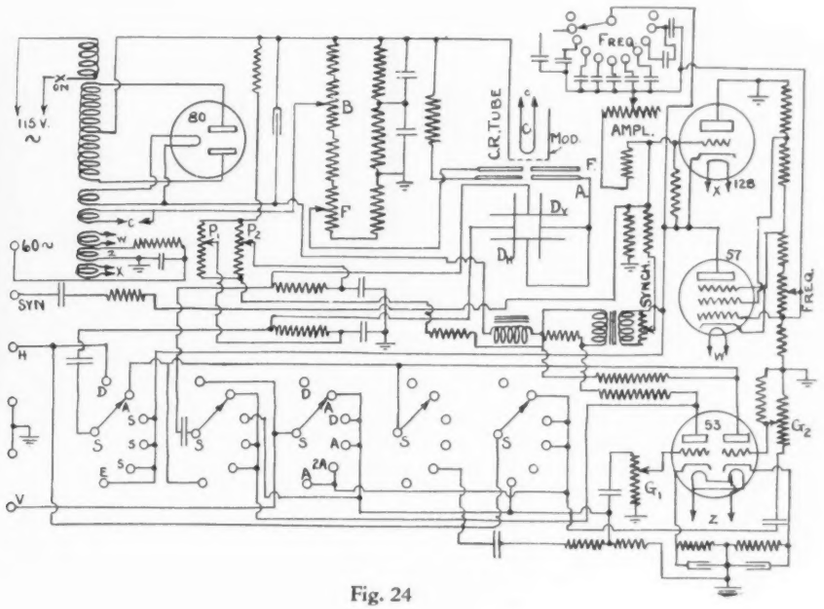


Fig. 24

Another popular equipment, the DuMont Laboratories' "Model 148" (Fig. 23), utilizes a somewhat different scheme, shown in the circuit diagram, Fig. 24. A capacitor selected by the frequency switch is rapidly charged to the full required value by the current passing through a heavy-duty Thyratron type of tube (type 128). When thus charged, this tube is automatically extinguished and the capacitor's charge is leaked off relatively slowly through the normal plate circuit of the pentode (type 57) shunting it. The linearity of this type of circuit will depend on the efficiency of the pentode in keeping the discharge current constant, and on the elimination of all other leakage paths. The charging voltage in this circuit is much higher than required for a maximum deflection, and but one rectifier tube is used. At the lower left corner of this circuit diagram is shown a five-gang switch which controls the connections to the deflection plates. In some other respects this circuit is similar to that shown in Fig. 21 in the February installment of this series.

LINEARITY CONDITIONS

In the determination of frequency ratios and certain other studies with a cathode-ray oscillograph, it usually is immaterial whether the time base has exact linear characteristics or not, but for the study of wave-form more rigid requirements are necessary. Inspection of an oscillogram will show the extent of the divergence since successive cycles intersect the horizontal axis at non-uniform intervals, whenever the sweep is operating non-linearily. In such cases the amplitude of the horizontal sweep potential can be increased until but one or two cycles of the measured wave appear on the screen. Since small portions of an exponential curve near the origin are substantially linear, the resulting horizontal deflection is proportional to time. It is of course necessary that the sweep frequency be at an exact sub-multiple of the measured frequency.

A sine wave oscillator can be used in this way to produce a linear time base, provided that no harmonics appear in the wave form of the driving frequency. For this purpose a separate winding on the power transformer can be provided to furnish the sinusoidal sweep potential, for studies of frequencies considerably greater than 60 cycles. The maximum potential should have a peak value several times that necessary to deflect the spot from one edge of the screen to the other.

If such a winding is not available, a five-volt filament transformer can be connected across the filament of the power supply rectifier tube in such a way that the trans-

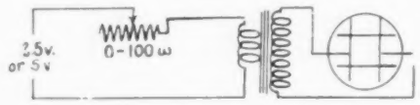


Fig. 26

former steps up the voltage applied to the deflection plates, as in Fig. 26. The rectifier filament is usually at ground potential so that the insulation requirements for the step-up transformer are not unusually rigid.

LOGARITHMIC TIME BASE

In many test problems, such as the delineation of the frequency response of audio amplifiers, a logarithmic time base is desirable. An arrangement shown by Diamond and Webb[11] employed a motor-driven carbon rheostat made from two semicircular carbon strips over which a rotating contactor continually swept. The thickness of these strips was linearily tapered and it was shown that, in conjunction with a synchronously-driven beat-frequency audio oscillator with semicircular plates, logarithmic timing waves were obtained.

The exact curve required in any case depends upon the characteristic curve of the audio oscillator or other device used in the tests, it being assumed that the same

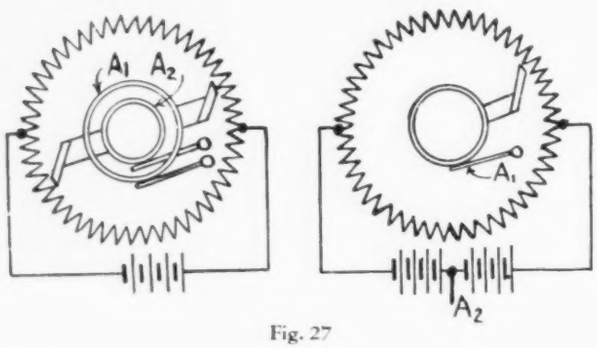


Fig. 27

motor drives the rheostat and the oscillator synchronously. In the usual case it is easier to design the beat-frequency oscillator to have a logarithmic scale and to use a linear time base, than to do the reverse.

A rotating commutator similar to the commutator on a d-c. motor can be provided with suitable resistors connected between successive contacts to produce any desired output curve. A graphic method can be used in the determination of the required values for these resistances: Draw the required curve on coördinate paper, with the number of horizontal divisions equal to two less than the total number of contacts on the commutator. The vertical values are proportional to one-half the total resistance desired. Since the terminals are to be connected across a direct potential source high enough to give a suitable horizontal deflection, the total resistance should be high enough to keep the current drain low. The resistance increment between successive contacts is then equal to the resistance values included by the curve between successive ordinates. For mechanical balance it is advisable that two rotating contacts be used. However, the two points of contact should not be exactly 180° apart. If one of the brushes is offset by an amount equal to one-half the width of the segment, the step-by-step appearance is reduced.

In the construction of a rotary rheostat to be used for time base purposes, the resistance element should be made of graphite with brushes of the same material pressing very lightly. If a harder grade of carbon is used for the resistance ring, roller contacts may be necessary for brushes, the rollers being of hardened steel to reduce the wear and to prevent a metallic deposit from appearing on the surface of the carbon. Several circuits are possible, of which the two most commonly used are shown in Fig. 27. In the one at the left, two brushes are provided, respectively connected to the deflection plates by means of slip rings, A_1 and A_2. In the right-hand diagram a single brush is used; the battery has twice the voltage; and the deflection plates are connected to the brush and to the center tap of the battery.

Such devices are practical for the study of low-speed mechanical problems, since the rotary brushes can be coupled directly to the device under investigation, but at higher speeds (such as several revolutions per second or over) the wear per hour of use of the rheostat is so much greater that frequent renewals are required.

RADIO-FREQUENCY LINEAR SWEEP OSCILLATORS

Certain investigators have substituted high-vacuum pentodes for the gas-filled discharge tubes used in the circuits heretofore described. With proper biasing of the control grid in the pentode, the plate current is kept below cutoff except for a small interval during the peak of each cycle of the applied frequency. The control frequency pulses are applied to the control grid, and act to drive the control grid a little above cutoff at the peaks. During the conductive intervals the plate circuit capacitor is discharged. The discharge that occurs takes place at a slower rate than with a gaseous discharge tube, so that the return interval of the sweep is somewhat longer.[12] These circuits, despite their relative complexity, are sometimes useful when there is required a sweep frequency higher than the upper limits practicable with a gaseous tube type of circuit. (For certain television applications a circuit by Zworykin[13] utilizes a tetrode—not a pentode—as the discharge tube, with the pulses triggered off by a dynatron oscillator.)

Pentodes have been used also with a dynatron type of circuit for the production of linear timing pulses. Sev-

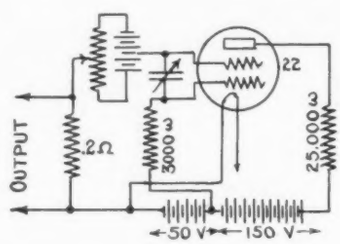


Fig. 28

eral types of relaxation oscillators disclosed by Page and Curtis[14] can, with amplification, be used for oscillographic work. One circuit is shown in Fig. 28.

Other types of relaxation circuits are based on the application of controlled feedback to resistance coupled

[11] Diamond & Webb. Testing of Audio-frequency Transformer-coupled Amplifiers. *Proceedings Institute of Radio Engineers*, Vol. 15, 1927, pages 767-792.

[12] Goldsmith & Richards. A High-frequency Sweep Circuit. *Proceedings Institute of Radio Engineers*, Vol. 23, 1935, pages 653-657.

[13] Zworykin. Experimental Television System and the Kinescope. *Proceedings Institute of Radio Engineers*, Vol. 21, 1933, pages 1655-1673.

[14] Page & Curtis. The Four-electrode Tube as a Relaxation Oscillator. *Proceedings Institute of Radio Engineers*, Vol. 18, 1930, pages 1921-1929.

amplifiers. A representative circuit of this type is shown in Fig. 29.[15] Another arrangement has been published by Rider[16] and is shown in Fig. 30. A commercial example of the Bedell[17] time base circuit has been developed by the General Radio Co.[18] This equipment, Fig. 31, can be applied to the deflection plates of any tube.

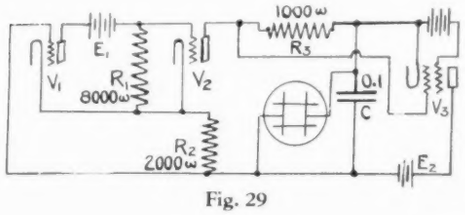


Fig. 29

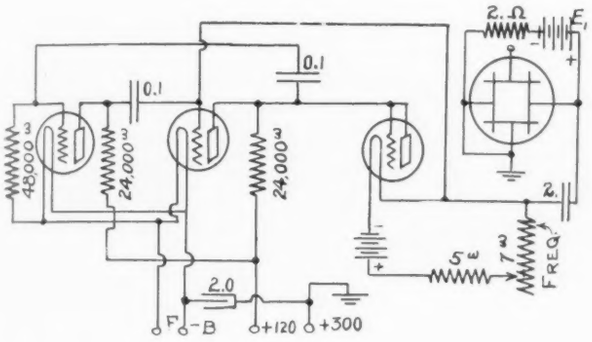


Fig. 30

Several other types of oscillators have been disclosed which use high-vacuum tubes in the discharge circuit in order to give a sawtooth wave. The one shown in Fig. 32 (British patent 235254: Appleton, Watt and Herd, 1924) is probably the best-known example.[19, 20, 21] In brief, the grid capacitor C in an oscillating circuit is charged by the rectified high-frequency oscillations (1 to 3 megacycles) in the grid circuits, such that the grid becomes highly negative and cuts off any plate current after a certain voltage. The charge accumulates so rapidly that the travel of the spot across the screen is practically instantaneous. The result of this charge is to block the oscillations and the condenser is permitted to dsicharge slowly through a grid leak. The use of a saturated diode* holds the discharge current to a constant value so that the spot returns at a uniform speed.

In this circuit the frequency is controled by adjusting the filament current of the diode, and E_x is used for centering or shifting the axis. As soon as the potential across the condenser drops to a certain value oscillations resume and the action is repeated.

Although this action is the reverse of that in a glow lamp oscillator (in which a slow charge and a rapid discharge is utilized) the effect is equivalent and the same form of oscillogram will be obtained.

It is claimed that an extremely sharp wave front is produced when C is small and the oscillator frequency high; that the wave form of the rest of the cycle is substantially linear if the diode circuit is correctly adjusted; and that the electrostatic coupling between the pairs of deflection plates is ordinarily sufficient to maintain synchronism if the frequency difference is not great. It is possible that the common impedance between the unknown and the timing wave circuits due to the common connection between one plate of each pair of plates (found in the tube used in the English investigators' studies) might have contributed some of this coupling, as the keeping-in-step feature (according to the present author's experience) is less noticeable with tubes having separate deflection plate leads.

It is claimed further that the effective conductivity through the diode is sufficiently high to minimize the importance of the leakage due to the deflection plates' conduction through the tube. The indicating spot travels

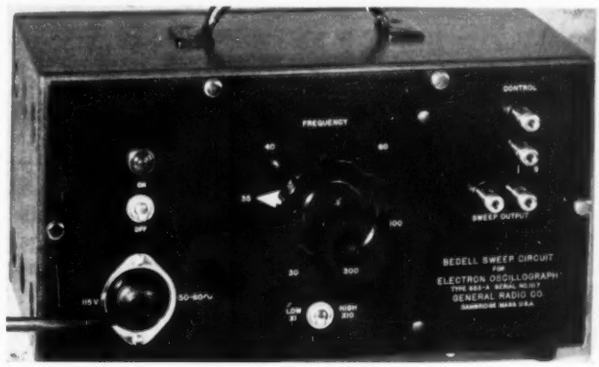


Fig. 31

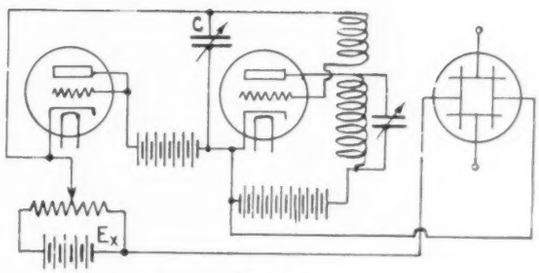


Fig. 32

uniformly across the screen at the frequency determined by the capacity of the grid condenser and of the filament current to the diode. The return is so rapid (it is claimed) that this sweep frequency can be adjusted from a fraction of a cycle per second up to values greater than ten kilocycles.

TIME BASE CIRCUITS FOR USE WITH DEFLECTION COILS

Deflection coils cannot be connected to the usual time base oscillator without amplification. While such coils can be designed to give full-scale deflection with a few ampere-turns, still the energy which must be dissipated during the short discharge interval is rather large and it cannot be handled with the usual gaseous discharge tube. When amplification is used, the steady potential drop across the coils must be balanced out in some way so that the normal position of the spot on the screen is wherever desired. Circuits have been disclosed by Zworykin[13] and others for use with tubes requiring magnetic deflection control. At best, however, satisfaction can be ob-

[15](Author's name in Japanese only.) On the Relaxation Oscillator Applied to a Braun Tube. *Journal of the Electrochemical Society of Waseda*, Vol. 15, 1934, pages 63-72.

[16]Rider. The Cathode-ray Tube at Work. Radio & Technical Publishing Co., New York, 1935.

[17]Bedell. Synchronizing Time Base. U. S. Patent No. 1707594.

[18]Scott. A New Sweep Circuit for the Electron Oscillograph. *General Radio Experimenter*, Vol. 8, Dec. 1933.

[19]Appleton, Watt & Herd. On the Nature of Atmospherics. *Proceedings Royal Society*, Vol. 111, 1926, pages 615-677.

[20]Appleton & Builder. Wireless Echoes of Short Delay. *Proceedings Physical Society of London*, Vol. 44, 1932, pages 76-87.

[21]Watson-Watt. The Cathode-ray Oscillograph in Radio Research. H. M. Stationery Office, London, 1933.

*See footnote in Feb. 1936 article, page 39.

tained at low sweep frequencies only, by reason of the frequency characteristics of the coils themselves.

General-purpose amplifiers have been developed for use with deflection coils, as for instance the circuit shown in Fig. 33.[22] The second stage of this arrangement must have a low-impedance output tube, so that a large current variation occurs in the plate circuit. To this end, it was suggested that two or more tubes be used in parallel in this stage (two to ten type 2A5 or 42 tubes were used), in order that sufficient ampere-turns be obtained with fewer deflection coil turns. A large impedance (three 50-henry chokes in series) supplies the plate current to the tube, permitting the use of a capacitor in series with the deflection coils to prevent magnetic saturation.

If a direct current is suddenly applied to the terminals of a pair of deflection coils, the current will at first rise almost linearly with time, provided that the value of L/R is large compared with the time (t) of the traverse. That is, $i = (E/L) \times t$. The maximum speed will depend on the inductance of the deflecting coil itself, so that for the more rapid deflections it may be necessary to use air-cored deflection coils. As mentioned in a previous article of this series, the iron core has a tendency to retain some of the magnetism, so that the spot will not be restored to its normal position after the first traverse.

For a succession of time base pulses using such coils, the exponential curve usually obtained can be changed to a more nearly linear one by connecting a condenser in series with the coils. To accomplish this, the resistance of the circuit must be greater than $2\sqrt{(L/C)}$ and the timing interval between discharges is less than (preferably less than half) the time indicated by:

$$t = (L/S) \times \log_e \sqrt{[\,(R + S)/(R - S)\,]}$$

where L = inductance of the pair of coils in henries;
$S = \sqrt{(R^2 - 4L\ C)}$;
R = ohms resistance in the LC circuit. If this resistance is too low, the circuit will tend to oscillate, which would defeat its purpose as a timing circuit.

It is possible to substitute such a combination of a selected inductance and capacity in series, for the condenser in the usual sweep circuit. The inductance can comprise the deflection coils, and the series condenser the value determined from the above relation. Such an arrangement will function at a higher frequency than is possible with the same deflection coils used alone. If the operation is slowed down however, a sinusoidal output wave is obtained which is not useful as a time base.

MISCELLANEOUS TIMING ARRANGEMENTS

In the study of recurring phenomena where a linear and synchronized time base is used, it often is essential that slight variations in successive pictures be distinguishable. Screen phosphorescence combined with persistence of vision produce on the retina a diagram in which these deviations are superposed and are, therefore, not discernible by observation. Even with good focusing, the slight variations in the recurring pulses under study may broaden the visible trace so much that accurate measurements cannot be made.

Then, too, in the study of irregular pulses, such as noises, static, etc., it ordinarily is impossible to tell whether certain effects occur in the same sweep or on separate time base intervals. This effect is not easy to deal with in most cases. It may be possible to view the diagram by reflection from a relatively slow speed rotating mirror so placed that the axis of rotation is parallel to the time base axis of the diagram. In this case, successive pictures are displaced in a vertical direction and the trend of minor varaitions can be noted more easily.

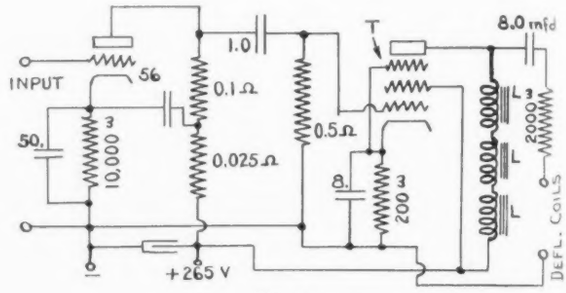


Fig. 33

For use in the study of static pulses, Appleton devised a similar scheme, with the vertical displacement produced by an auxiliary low-frequency linear oscillator (10 cycles) upon whose pulses are superimposed the static pulses being investigated.

MULTIPLE CONTACT SWITCHES

In the application of cathode-ray tubes to some types of tests and developments, the author has utilized to good advantage step-by-step mechanical switches as shown in Fig. 34. For the horizontal time base the terminals of one arc of the switch bank (which contains twenty or more useful contacts) are connected to the junction points of a series of small fixed resistors as shown in Fig. 35. In order to reduce the jumps in the deflection potential as the switch advances to each new contact, a

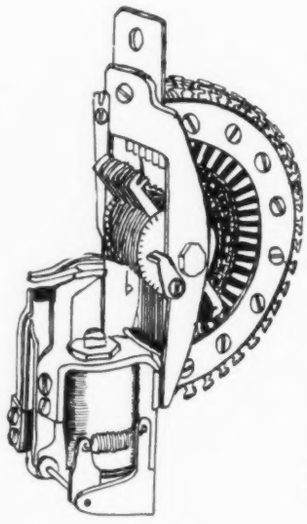


Fig. 34

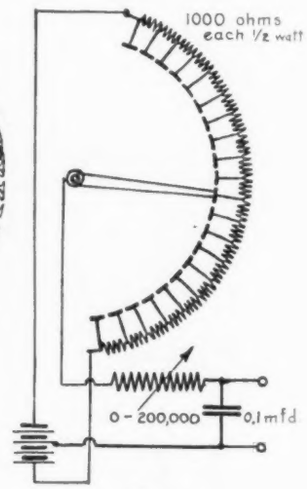


Fig. 35

tank or filter circuit is utilized. The values of the elements in this filter depend upon the speed with which the switch advances when self-operated.

By means of a strong electromagnet and a ratchet and pawl this switch can be connected to rotate continuously at a speed of the order of 60 r.p.m. or, if desired, several stops can be effected during a revolution. Alternatively, the switch can be advanced one step at a time under the control of a switch or key: either manually, or automatically from pulses obtained from the equipment under test.

Several additional switch arcs, available also on the same switch bank, can be utilized in controlling the cir-

[22] Anon. Cathode-ray Tubes. RCA Radiotron Division, *Technical Series, No. 2.*

cuit under test. Specific applications of this mechanism, wherein staged tests with a predetermined set-up of conditions can be brought about, will be outlined in a later article. For the superposition of two or more recurring and inter-related curves the extra banks can be split and the sections wired as needed to the circuits under investigation. The transitions then occur at a relatively slow rate, however, and a flicker results during visual studies.

MULTIPLE DIAGRAMS

Many other arrangements have been in use to superpose two related wave-forms on the same oscillogram. A common method utilizes some type of commutator to connect alternately the two waves to the same deflection

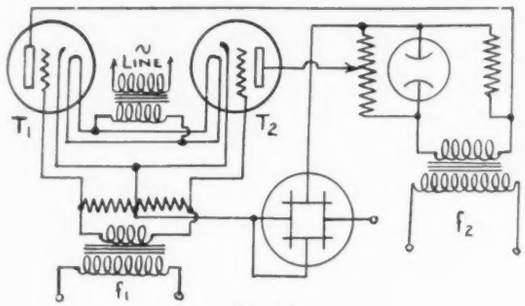


Fig. 36

system. Commutators driven by synchronous motors are frequently arranged to stage some special set-up and to initiate certain circuit conditions at a definite time (such as triggering off surges, etc.) in addition to actually switching in two wave-forms alternately. In some of these devices it is possible to arrange conditions so that phase relations between the superposed portions of the diagram can be studied.

The inherent disadvantage of a single-element oscillograph such as the cathode-ray arrangement has started many investigators on possible solutions. Multi-element cathode-ray tubes are not new, as for example several arrangements were used by DuFour[23] in his studies of high-tension circuit phenomena. In such tubes several electron guns each project a jet on the same fluorescent screen. It is of course necessary that the deflection systems have equal sensitivities—at least along the common time axis if photographic recording is not utilized.

A double-element oscillograph wherein the two waves are projected on opposite sides of the screen has been shown by Feoktistov.[24] A résumé of various arrangements has been given by Garceau.[25] With the usual single-jet tube, a common method has been to utilize a commutating scheme. Actual circuits which have been employed for electronic switching have been disclosed recently by George, Heim, Mayer and Roys,[26] by Woodruff,[27] by Davidson,[28] by Hughes[29] and by Sewig.[30] The circuit used by the latter is shown in Fig. 36. In another device, Fig. 37, made available by the DuMont Laboratories, the two input waves are both applied to the vertical deflection plates, through two high-gain single-

Fig. 37

stage amplifiers. By alternately blocking these amplifier stages by rapidly changing their biases to the cutoff point, only one tube is operating at a time. Three controls are provided externally, two of which are utilized to vary the gain of the two amplifier stages, and the third to adjust the rapidity of the switching.

Among the aplications of these commutating arrangements are the relative comparison of input and output wave-forms of an amplifier, time studies, frequency characteristics, and many other tests which will be described in detail in later articles.

[23]Dufour. L'Oscillographe Cathodique pour l'Etude des Basses, Moyennes et Hautes Fréquences. Etienne Chiron, Paris.

[24]Feoktistov. Double Cathode-ray Oscillograph. *Russian Journal of Technical Physics*, Vol. 4, 1934, page 332.

[25]Garceau. Duplex Cathode-ray Oscillograph. *Review of Scientific Instruments*, Vol. 6, 1935, pages 171-172.

[26]George, Heim, Mayer & Roys. Cathode-ray Oscillograph for Observing Two Waves. *Electrical Engineering*, Vol. 54, 1935, pages 1095-1100.

[27]Woodruff. Multielement Operation of the Cathode-ray Oscillograph. *Electrical Engineering*, Vol. 54, 1935, pages 1045-1047.

[28]Davidson. A Double-wave Device for Use with Cathode-ray Oscillograph. *Journal of Scientific Instruments*, Vol. 11, 1934, pages 359-361.

[29]Hughes. Thyratron Selector for Double-trace Cathode-ray Oscillograph. *Review of Scientific Instruments*, Vol. 7, Feb. 1936, pages 89-92.

[30]Sewig. Simultanaufzeichnung mehrer Vorgänge. *Zeitschrift für Technische Physik*, Vol. 14, 1933, pages 152-153.

INSTRUMENTS' BOOK SHELF—*continued from page 76*

Modern Radio Servicing. By ALFRED A. GHIRARDI. Radio & Technical Publishing Co., New York. 1935. Fabricoid, $5\frac{3}{4}$ x $8\frac{1}{4}$ inches, xii + 1300 pages. Price $4.00.

Supplement: **Radio Field Service** Data. By A. A. GHIRARDI and B. M. FREED. Radio & Technical Publishing Co., New York, 1935. Paper, viii + 240 pages. Price $1.50.

Comparison of today's radio receivers with those of a few years back will dispel any impression that receivers are becoming standardized. Servicing is becoming a highly specialized profession. As a rule, with the intricate circuits now in use, troubles are not immediately discernible and can only be found by a series of planned tests. Even if a circuit diagram of the particular set is available, it usually is desirable to make repairs as soon as possible. The procedures of finding the trouble, sending in for a new replacement part, and then replacing it and testing when it arrives, usually require so much time that it is disappointing to the owner. To spot troubles immediately and make repairs quickly takes technical skill of a high order, even if the circuit diagram of the particular set is available.

The whole field of servicing and repairs as covered by the questions "what, where, why and how," has at last been tackled—in a volume so complete that it attracts the interest of everyone who sees it. With infinite patience the author describes everything, leaving nothing to the imagination. What to look for, what tools to use, test equipment (in many cases the construction of test equipment is described), details of all parts, possible repair methods, readjustment of all circuit variables, and many other details are completely described. Even sales suggestions and improved business methods in this field are outlined.

In 1300 well-indexed pages, comprising 32 chapters, with more than 700 illustrations, the book constitutes an invaluable reference not only for the radio service man but for the engineer. It also is useful as a self-instruction and home-study course. Toward this end an extensive list of questions is included in each chapter, by which the reader can check up whether he has missed any important points in the discussion. The author is to be congratulated on this latest contribution to the field, following up his other useful text on Radio Physics.

Since the book is rather bulky, a supplement, "Radio Field Service Data," is available which gives concise information of the type that a service man may require in the field away from his laboratory. It deals with both home receivers and automobile sets, and contains many tables and charts of a useful nature. In this supplement the author give also the answers to the questions listed in the main text.

P. R. BATCHER. (5)-B-

Continued on page 87

Rawson Twin Multimeter

29 ranges in less space than any near equivalent combination—size 12″ x 8″ x 6″

RANGE OF MEASUREMENTS

D.C. 1 microampere to 1 ampere
20 microvolts to 1000 volts
A.C. (up to 3000 cycles)
2 milliamperes to 3 amperes
60 millivolts to 1000 volts

List Price $165.00

The Rawson measuring instruments are the only ones having two pivot movements whose weight is lifted from jewels when clamped for transit. Electrical clamping does not accomplish this purpose.

Special apparatus built to order

RAWSON ELECTRICAL INSTRUMENT COMPANY

110 POTTER ST., CAMBRIDGE, MASS.
Branch: 91 Seventh Ave., New York City
Representative: E. N. Webber
1217 Washington Blvd., Chicago, Ill.

ROLLER-SMITH
'STEEL-SIX" PORTABLES

A.C. and D.C. Ammeters, Voltmeters, Wattmeters, Frequency and Power Factor Meters

1. Steel cases for shielding and strength.
2. Convenient size, about 6″ square.
3. Long scale, 5 3/16″; open and well lighted
4. Good accuracy, 5% D.C.; 1% A.C.
5. A *real* instrument in *every* detail.

Send for Catalog J-123

ROLLER-SMITH COMPANY
Electrical Measuring and Protective Apparatus

Main Office
2132 Woolworth Bldg.
New York, N. Y.

Works
Bethlehem
Penna.

TOTALIZING

Twenty-seventh instalment of "Electrical Measurements and Control." This series began in the January 1934 issue. See announcement on editorial page of November 1933 issue. All rights reserved by the authors.

By PERRY A. BORDEN and M. F. BEHAR
Member A.I.E.E. Editor, *Instruments*

3. Mechanical Totalization of Impulses.

The totalization of impulses from various sources, each impulse representing a predetermined unit of increment at its source, is in general more effectively solved by mechanical than by electrical means. The only special problem involved is to take cognizance of concurrent impulses from different sources, giving each its weight in the ultimate summation.

Sangamo System.

In the Sangamo Electric Co.'s "Distant Dial" system of telemetering[7] the problem of accounting for the irregular spacing of impulses is more or less effectively solved by the simple expedient of utilizing impulses of alternate polarity originating in one transmitter, and fitting each additional transmitter with a quick-acting reversing commutator, shown diagrammatically in Fig. 45-9 and photographically in Fig. 45-10. The receiving instrument responds to reversals only; and the small proportion of the total time required to make a reversal minimizes the probability of simultaneous occurrence of reversals in different transmitters; so that the resulting possible error in totalizing is claimed to be negligible.

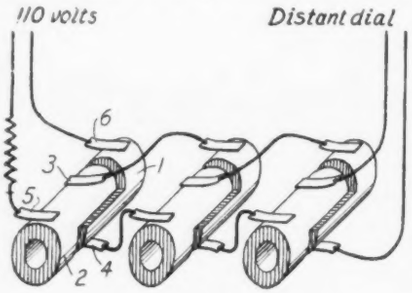


Fig. 45-9

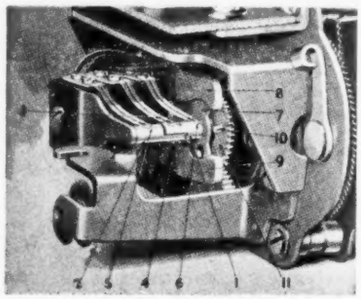


Fig. 45-10

[7] *Instruments*, January 1936, page 16.

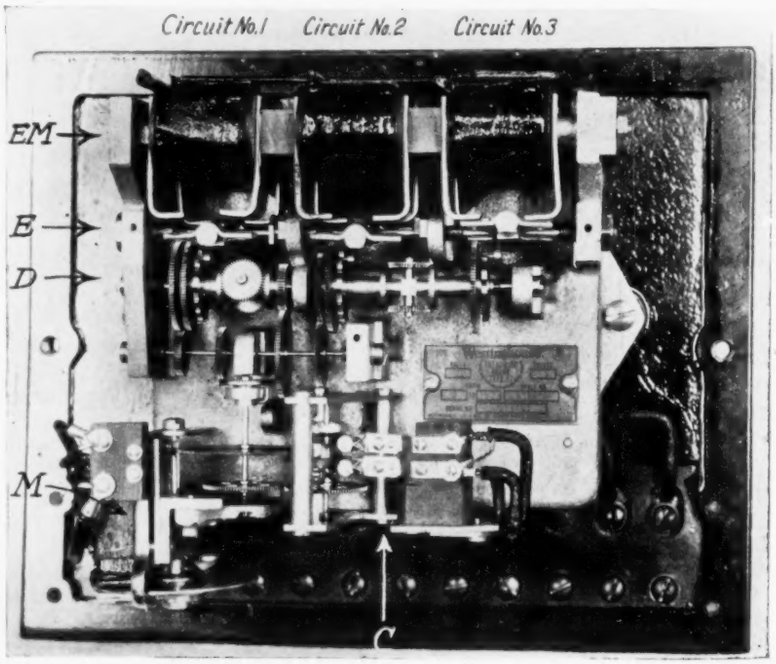


Fig. 45-11

Westinghouse Impulse-totalizing Relay.

The Westinghouse totalizing relay, Fig. 45-11, has three elements, and can therefore totalize three independent sets of impulses (each from a 3-wire transmitting unit) representing the speeds of as many separate remote meters. Greater numbers can be totalized by using more than one relay, each then transmitting totalized impulses by means of contact device C. A small torque motor M maintains (through a spring which it keeps wound) a constant driving force on a set of differential trains *D*, each of which is released by an escapement *E* operated by an electromagnet *EM* actuated by the received impulses. From the combined action of these escapements and differentials a driving shaft is caused to advance at a speed representing the total of the incoming impulses, and either drive directly a demand meter or originate a new set of electrical impulses to be re-transmitted. The electromagnets—and hence the system—can operate on a-c. or d-c.

General Electric Totalizing Relay.

In the General Electric Co.'s. totalizing relay, of which Fig. 45-12 shows the four-circuit form, use is made of a system of differential gearings. By combining a number of differential units it is possible to totalize any desired number of impulse groups, and express the summation either by a new set of impulses or by direct deflection of a moving indicator. The principle of operation is shown in Fig. 45-13:

Each remote meter (electricity, gas, water, etc.) is equipped with an impulse transmitter connected by a three-wire system to a set of solenoids *A* and *B*. The solenoids operate pawls *C* and *D* thereby advancing crown wheels *E* and *F* so that ring gear *G* rotates an

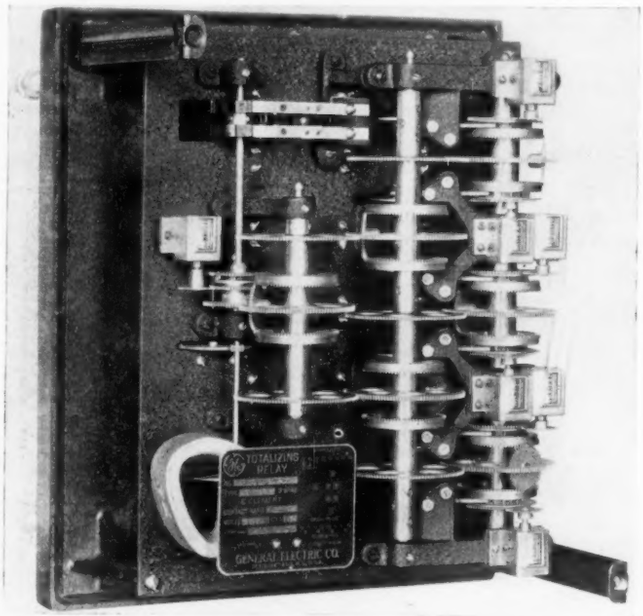


Fig. 45-12

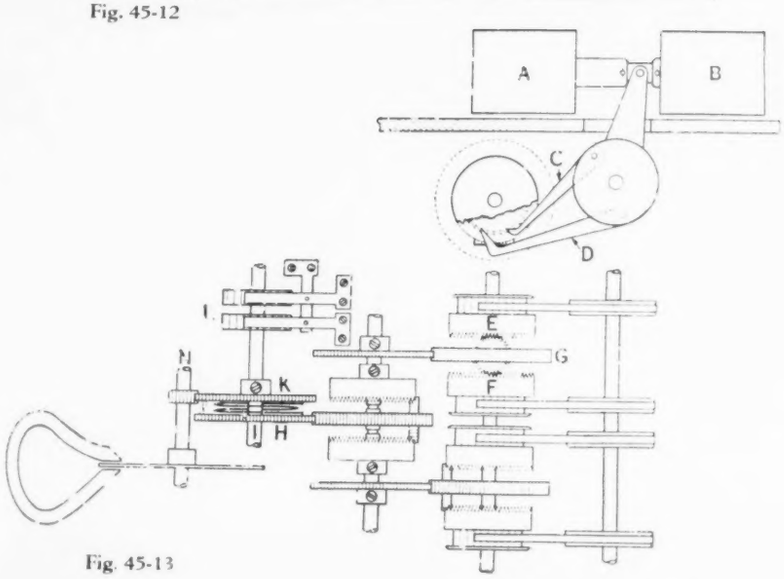
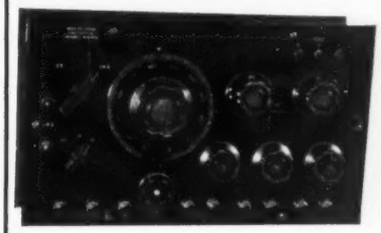


Fig. 45-13

TYPE B POTENTIOMETER



A high grade precision potentiometer for general laboratory use. Highly accurate and convenient. Three ranges: 1.6 V., 160 M.V. and 16 M.V.

Ask for Bulletin No. 270.

RUBICON COMPANY

Electrical Instrument Makers

29 N. Sixth Street, Philadelphia, Pa.

Resistance Boxes. Wheatstone and Kelvin Bridges. Potentiometers. Galvanometers. Electrometers. Standards of Resistance, Inductance and Capacitance. Coil Testing Instruments. Magnetic Testing Apparatus. Split Core Transformers. Magnaflux Equipment. Nitric Oxide Recorders.

SPECIAL APPARATUS BUILT TO ORDER.

SHALLCROSS

WHEATSTONE BRIDGE

Reliable *Inexpensive*

Range 0.01 Ohms to 11.1 Megohms

This Wheatstone Bridge is built around a highly sensitive galvanometer and Shallcross resistors.

A simple and rugged yet accurate instrument capable of resistance measurements from 0.1 ohms to 11.1 megohms.

Send for Bulletin 631-HA describing this instrument.

SHALLCROSS MFG. CO.

COLLINGDALE, PA.

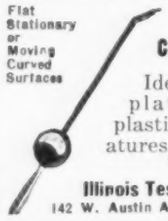
Acquire the Inventive Habit through special training

The inventive ability you now possess will not become a financial asset unless you convert it into what industry needs: the *habit* of producing technical ideas. Send for details of our home-study course.

Dep't EI—TROFIMOV SCHOOL of INVENTIVE PRACTICE, Inc.
3859 Northampton Road, Cleveland Heights, O.

Surface Temperatures

Flat Stationary or Moving Curved Surfaces



The "Alnor" Combination Pyrocon

Ideal for rolls, molds, plates, platens and plastic material temperatures.

Write for bulletin.

Illinois Testing Laboratories, Inc.
142 W. Austin Ave. Chicago, Illinois

"ALNOR" VELOMETER
(Boyle System)
Instantaneous Direct Reading Air Velocity Meter
20-feet to 6000-feet per minute
Write for Bulletin

Illinois Testing Laboratories
Incorporated
142 W. Austin Avenue
Chicago, Illinois

20 mm. or 0.5 μ
High vacuua or accurate gas pressure.

Electric Vacuum Gauge
(Pirani type)
folder on request

WINSLOW ENGINEERING CO.
138 SUSSEX AVE. NEWARK, N. J.

The New Science of "Robot" Control

Is formulated for the first time—and many of the modes of control which can be obtained with commercially-available automatic controllers are analyzed — in Béhar's handbook,

FUNDAMENTALS of INSTRUMENTATION

which contains also chapters on the properties of measuring instruments, on how to run an instrument department, and on other essentials of your job.

$2.00 postpaid

Instruments Publishing Co.
1117 Wolfendale St. Pittsburgh, Pa.

amount equivalent to the summation of the rotations of crown wheels *E* and *F*. The movement is transmitted to a second differential train which sums up the advances made by the two initial differentials and transmits this motion to gear *H* which is mounted loosely on contact shaft *I*. Gear *H* is connected by means of a coil spring to gear *K* mounted rigidly on the contact shaft and located definitely with respect to *H* by two small contact pins held together by a definite tension in the spring. After gear *H* is advanced, its pin moves ahead of the pin on gear *K*, and the spring, then being free to act, moves gear *K* ahead until its pin stops against the pin on gear *H*. This motion in gear *K* is transmitted to the contact shaft which rotates the contact cams *L* and transmits the proper number of impulses through a three-wire circuit to a demand device, another totalizing relay, etc.

Shaft *N*, carrying a disk running between the poles of the drag magnet, is geared to shaft *I*, the drag slowing up the motion of the shaft so that the impulses from the several three-wire circuits are re-transmitted at a rate slow enough to be recorded by a demand device mechanism. Thus, if impulses were received simultaneously on the four sets of solenoids, and assuming a "contact ratio" of 1 to 1, gear *H* would be advanced four contacts ahead of gear *K*. Gear *K*, however, would rotate shaft *I* at a speed determined by the drag magnet so that, although the four impulses were received at the same instant, they would be re-transmitted slowly and individually through the three-wire contact mechanism.

Landis & Gyr Summation Meter.

The "Elgee" summation meter, produced by Landis & Gyr, employs a totalizing relay in which the register of the meter is advanced by a system of ratchets receiving impulses controlled by contacts on independent meters and totalizing the effects of the impulses without respect to their relative times of occurrence. A diagram of this device arranged for totalizing the readings of four contacting meters is shown in Fig. 45-14:

When any one of the relays is energized its armature is attracted, thus releasing lever 1 which, under action of spring 6, moves toward cam shaft 3 which is driven continuously by a small shaded-pole motor 8. During this movement of lever 1 a pawl 9, carried thereby, slides over the teeth of a corresponding ratchet wheel 5. Lever 1, on the end remote from pawl 9, has a projection which is engaged by cam 2, pressing the lever back until it is locked by a detent on the armature of the relay. During this return motion of lever 1, wheel 5 is engaged by pawl 9 and moved one tooth in the direction shown by the arrow.

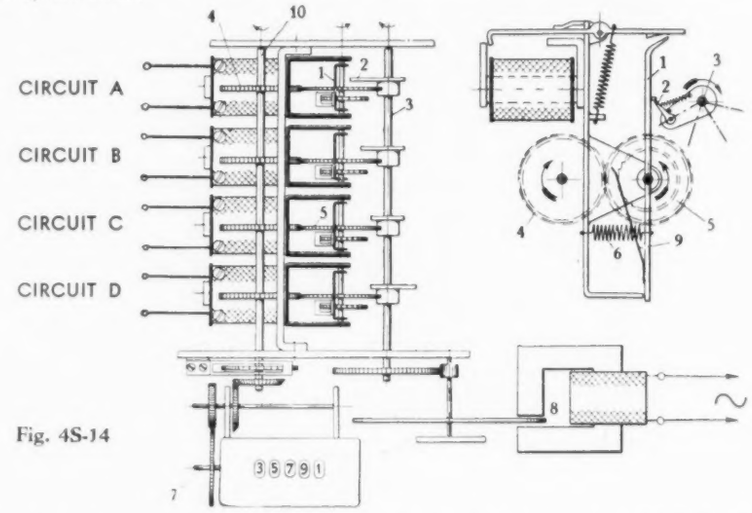


Fig. 45-14

The wheels 4 are mounted on a common spindle 10, which is geared to dial 7. It will be noticed that cams 2 are staggered about shaft 3, so that even if a number of the relays are energized simultaneously by concurrent impulses, the resetting of the levers and the consequent advances of the register can take place only in a definite sequence, so that no impulses are lost.

A further refinement in Landis & Gyr's totalizing equipment, the "Impulse Regulator," forms a valuable accessory where it is required to connect several sub-totalizers to a single master totalizer. In such cases, unless special precautions are taken, the rate at which impulses are received by the master totalizer will at times be too high, while intervals will occur when no impulses are received. The impulse regulator acts to store up impulses received irregularly and send them out to the master totalizer at regular intervals. It also is possible, for instance, for (say) four incoming impulses each representing 1 kilowatthour to be re-transmitted as a single impulse representing 4 kilowatthours. The principle of operation is shown in a simplified form in Fig. 45-15:

One end of a differential gear train is advanced by the successive impulses, through gears 5 and 4. The other end of the train is driven through gears 7 and 6 from the disk 1 of a shaded-pole motor, which, through gear 8 also drives the contacts for re-transmitting the impulses. The planetary wheel 10 rolling on the gears 2 and 3 of the differential, serves to operate a brake 9 which can engage the motor disk, the latter always tending through the train to move the brake to a position where it will stop the motor. Any movement of the wheel 2, i.e., any impulse received, will displace the

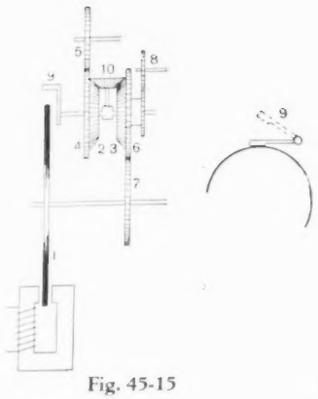


Fig. 45-15

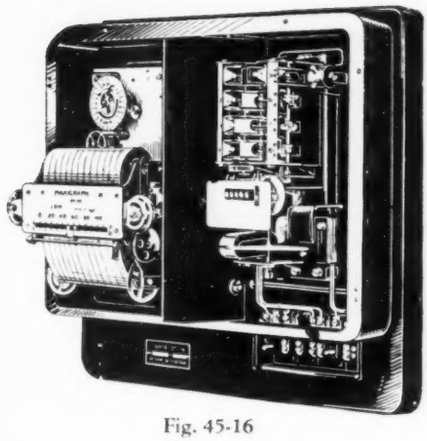


Fig. 45-16

planetary 10, releasing the brake from the disk, whereupon the motor, driving the disk at a constant speed, operates the contact device through gear 8, and transmits a series of regularly spaced impulses. At the same time, the planetary 10 will tend to restore brake 9 to its position of engagement with the disk, thus bringing the motor to rest as soon as there has been transmitted a number of impulses equivalent to those received.

4. Application of Telemetering Principles to Totalizing.

The subject of totalizing, as has already been pointed out, cannot be divorced from other branches of electrical measurement, particularly from telemetering. A discussion of the application of telemetering principles to totalizing can be little more than a recapitulation of statements already made in this or earlier articles. A brief review may however be made of the suitability of the essential principles of the several systems to the problems of totalizing.

Voltage and current systems, within the limits of the circuits involved, lend themselves well to the totalization of scalar magnitudes which may be represented by d-c. values. Mention has previously been made of a limitation of the current system, in that as currents from diverse sources connected in parallel are forced into a common transmitting circuit the voltage across the terminals of the circuit must be increased, requiring that each of the transmitters must raise its voltage in response to any increase of transmitted current. Thus, not only is there a possibility of "pumping" between transmitters, but the transmitted current is limited by the voltage of the weakest transmitter in the group, as related to the resistance of the transmitting circuit and the receiving instrument. Since the passage of a measured current through a fixed resistance of predetermined value is represented by a proportional emf drop it is possible by the use of a standard resistor forming a portion of circuit common to a current system and a voltage system to add the drop across the resistor to that otherwise set up in the voltage system, and thereby perform summation between the two systems without resort to the use of transfer or re-transmitting devices. This renders possible the combination of a current system such as the Westinghouse or Midworth with a voltage system such as the Lincoln or L & N, the total being ultimately recorded on a self-balancing instrument.

The production of commercial frequencies proportional to measured values, as required for telemetering on the frequency principle, is not a simple matter; and the problem becomes more involved when it is attempted to produce a frequency representative of the sum of a group of frequencies. However, as the limitations on the use of frequency systems employing electronic devices are removed, the solution of totalizing problems by this class of system is being correspondingly simplified.

Position systems of telemetering are not inherently suited to totalizing; and, beyond such involved arrangements of position motors as those referred to in a previous article, the application of this principle requires more or less elaborate re-transmitting instruments in order that totalization may be effected.

The applicability of "impulse-counting" and "impulse-frequency" systems to the totalization of integrated values has been discussed in Section 3 of this article. In theory at least the impulse-duration system, which is primarily suited to indications or graphics records, can be applied to the summation of two magnitudes, by the use of a transmitting instrument in which one of the measured magnitudes varies the beginning, and the other the end, of the time interval. However, since this requires using transmitters having relatively intricate design, and bringing the two magnitudes under measurement to a common transmitting instrument, it generally is more expedient to effect summation of scalar magnitudes by some other method, such as floating levers or "whiffletrees" in the transmitting or receiving instrument.

MANUFACTURERS' NEW LITERATURE

In this department we list each month the printed matter issued by manufacturers. Unless otherwise noted, any of the items listed may be secured free upon application to the issuing firm.

D48 **Controlled Rectifiers.** Bulletin 8601, 1-page, covers Rectifiers for communication, laboratory, and similar uses requiring a constant d-c voltage with varying loads. Ward Leonard Electric Co., 38 South St., Mount Vernon, New York.

D49 **Optical Instruments.** Catalogue Mess 17E, 44 pages. This is an abridged catalogue covering: Spectroscopic Apparatus, Goniometers, Refractometers and special instruments for Optical-Crystal Determination. R. Fuess, Inc., 245 West 55 St., New York.

D50 **Potentiometer-Electrometer.** Circular EH22-D describes a portable model for measuring hydrogen-ion and oxidation-reduction potentials. Leeds & Northrup Co., 4955 Stenton Ave., Philadelphia, Pa.

D51 **Thermostats.** Bulletin T illustrates and describes: Wall Mounting Thermostats and Friez Insertion Thermostats. Instructions for installation are also given. Julien P. Friez & Sons, Inc., Baltimore, Md.

D52 **Voltage Regulation.** Catalogue B2056 discusses voltage regulation from the generator to the end of the line. A table giving the application of Westinghouse regulators is included. The following equipment is covered: Generator Voltage Regulators, Tap-Changing Equipment, Feeder-Voltage Regulators, Feeder-Voltage Boosters, Series Capacitors and Autotransformers. Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.

D53 **Electrostatic Voltmeters.** Bulletin E.S.V. gives complete data on Ferranti Electrostatic Voltmeters for a-c. and d-c. measurements. Ferranti Electric, Inc., 130 West 42 St., New York.

D54 **Air Operated Controllers.** Folder 84-2-30 illustrates and briefly describes the features of the Brown Air Operated Controllers. Minneapolis-Honeywell Regulator Co., 4482 Wayne Ave., Philadelphia, Pa.

D55 **Potentiometers.** Bulletin 270 describes the Type B High Precision Potentiometer as well as the portable precision potentiometers, Brooks Deflection Potentiometer, Precision and Simplified Laboratory Potentiometers and a Portable Slide Wire Potentiometer. Rubicon Co., 29 North 6 St., Philadelphia, Pa.

D56 **Piezo-Electric Calibrator.** Form 299 describes this calibrator for checking frequencies accurately. An accuracy of 2 parts in a million is claimed. RCA Mfg. Co., Inc., Camden, N. J.

D57 **Transformers** GEA-1358B, 8 pages are devoted to small transformers for control and signal circuits. Engineering data and specifications are included. General Electric Co., Schenectady, N. Y.

D58 **Flow Measurement.** Catalogue Mess 30E, 12 pages, illustrates and describes instruments for the measurement of flow, pressure and vacuum. R. Fuess, Inc., 245 W. 55 St., New York.

D59 **Windowstat.** Bulletin W describes a simple thermostat which overcomes the major problem of winter air conditioning. The excessive condensation that takes place on windows, badly insulated walls, or other cold surfaces. Julien P. Friez & Sons, Inc., Baltimore, Md.

D60 **Precision Stopwatch.** Leaflet HS 255 describes the Höppler Precision Stopwatch developed to use in conjunction with the Höppler Viscosimeter. Fish-Schurman Corp., 230 East 45 St., New York City.

D61 **Bearing-Temperature Relays.** Leaflet GEA-2209 covers an instantaneous, bellows-type, hand-reset relay for protecting machine bearings against abnormal heating. General Elec. Co., Schenectady, N. Y.

D62 **Oscillators.** Leaflet 208-C describes the Type CR-r frequency audio-oscillator. This circular illustrates the constructional details and gives the specifications for this instrument. Leaflet 209-C covers the Type CR-5 frequency modulated R.F. oscillator. This circular also covers details and specifications. United Sound Engr. Co., 2233 University Ave., St. Paul, Minn.

D63 **Draft Control.** Bulletin L-125 describes an electrically operated furnace draft control. The bulletin also contains a brief discussion of the value of draft control. Shallcross Controls Corp., Milwaukee, Wis.

D64 **Temperature Controller.** Bulletin No. 1127, describes the Tag No. 40 controller. This device is available in indicating and non-indicating types in nine convenient temperature ranges and three pressure ranges. C. J. Tagliabue Mfg. Co., Park & Nostrand Aves., New York City.

D65 **Tap Switches.** A bulletin covering a new line of quality tap switches is announced by the Tech Labs., 703 Newark Ave., Jersey City, N. J. In radio and electronic applications as well as in most instrument applications, better grade tap switches are necessary. These new switches are said to meet the requirements in every way.

D66 **Automatic Reset Timers.** Bulletin No. 780 covers the Type S and Type T timers. Zenith Electric Co., 607 S. Dearborn St., Chicago, Ill.

D67 **Open-Hearth Pressure Controller.** Circular 643 gives a brief description of the L & N automatic furnace pressure control for open-hearths. Leeds & Northrup Co., 4955 Stenton Ave., Philadelphia, Pa.

D68 **Ignition Velocity.** Bulletin No. 2012 describes and illustrates by diagrams the operation of the Hays ignition velocity meter. This bulletin also gives operating instructions for this instrument. A brief discussion of the meaning and importance of ignition velocity in fuels is also included. Hays Corp., Michigan City, Ind.

D69 **Anemometers.** Bulletin J illustrates several types of Biram types with prices. Julien P. Friez & Sons, Inc., Baltimore, Md.

D70 **Cathode Ray Oscillograph.** Leaflet 207-C gives specifications and constructional details of a portable AC operated oscillograph. United Sound Engr. Co., 2333 University Ave., St. Paul, Minn.

D71 **Smoke-Density Recorders.** Catalogue N-93 is an illustrated 16-page catalogue on Micromax smoke-density recorders. The equipment, the catalogue states, is rugged in construction, automatic in operation, and provides not only the information needed to follow small abatement schedules but clear fileable records as well. Leeds & Northrup Co., 4955 Stenton Ave., Philadelphia, Pa.

D72 **Hydrogen-Ion Meter.** 4-page folder describes the Beckman hydrogen-ion meter in which the galvanometer is replaced with a new multistage electric tube circuit, which is said to increase the accuracy of the determinations. E. H. Sargent & Co., 155 East Superior St., Chicago, Ill.

D73 **Square Electrical Instruments.** Leaflet illustrates the pointer square meter with unusually long scale. Ranges and prices of milliammeters, ammeters, standard voltmeters and high-resistance voltmeters are given. Burton-Rogers Co., 755 Boylston St., Boston, Mass.

INSTRUMENTS
1117 Wolfendale St., Pittsburgh, Pa.

Have me supplied with a copy of each piece of Manufacturers' Literature listed below.

.....

.....

.....

.....

Name.....

Position.....

Firm.....

Street and No.....

City..... State.....

D74 **Magnetic Contactor.** Folder No. 1140 covers the Type LTZ contactors for alternating current service. Electric Controller & Mfg. Co., Cleveland, Ohio.

D75 **Electric Recorders.** Bulletin R describes the new Friez round chart recorder for recording temperature and humidity. Julien P. Friez & Sons, Inc., Baltimore, Md.

D76 **Laboratory Stirrer.** Leaflet illustrates the Lab-Mix Sr. It is stated that the shaded pole type motor used in this stirrer can run 24 hours daily without damage. The stirrer can be used on 110 volts (50-60 cycle). Chemical Publishing Co. of New York, Inc., 175 Fifth Ave., New York City.

D77 **Draft Gauges.** Bulletin No. 33-A describes the Defender pointer type draft gauges, made in 1, 2 or 3 pointers in a single aluminum case. The Defender Automatic Regulator Co., 308 S. 18th St., St. Louis, Mo.

D78 **Speed-Measuring Instruments.** Bulletin 1435 describes several portable speed measuring instruments. Type C hand tachometer (Jagabi), hand tachograph (Jagabi), tachonorm (Jagabi), tachoscope (Jagabi), chronometric tachometer and a hi-speed indicator for speeds up to 100,000 rpm. James G. Biddle Co., 1211 Arch St., Philadelphia, Pa.

D79 **Polarizing Microscopes.** Catalogue D-130, 24 pages, contains a brief introduction for those who have never worked with a polarizing microscope. Several models are described and illustrated and prices are given. Bausch & Lomb Optical Co., 615 St. Paul St., Rochester, N. Y.

D80 **X-Ray Inspection.** Pub. 7A-37 illustrates an inspection unit and conveyor for the continuous inspection and examination of foods. Illustrations show some of the foreign materials which are located by the use of this method. Pub. 8A-27 illustrates an inspection unit for use with candy. Full sized X-Ray photographs show the presence of stones, pins, and other foreign bodies. The General Electric X-Ray Corporation, 2012 Jackson Blvd., Chicago, Ill.

D81 **Distant Reading Electric Thermometers.** Bulletin No. 2451, 8 pages, discusses resistance thermometers and illustrates the various indicators available. Illinois Testing Labs., 142 W. Austin Ave., Chicago, Ill.

D82 **Hydrogen Ion Recorder.** Bulletin 709-B, 12 pages, illustrates the application of the Micromax hydrogen ion recorder for improved gassing of beet juices. This bulletin gives installation photographs, typical layout diagrams, equipment specifications and mounting dimensions. Leeds & Northrup Co., 4955 Stenton Ave., Philadelphia, Pa.

D83 **Rubber Plated Steel Laboratory Supports** are illustrated and briefly described in a 6-page folder of E. H. Sargent & Co., 155 E. Superior St., Chicago, Ill.

D84 **Solving Industrial Crimes, Case No. 10.** This booklet illustrates how a mill manufacturing fiber products reduced its cost 25% by the application of recorders. A large number of applications in other industries are listed. Esterline-Angus Co., Indianapolis, Ind.

D85 **Johansson Gage Blocks.** 6-page leaflet gives complete data on Set No. 2, which consists of 35 blocks and 4 accessories. A conversion table of fractions of inches, decimals and millimeters is included as well as rules for calculating areas, circumference and diameter. Ford Motor Company, Johansson Division, Dearborn, Mich.

D86 **Micro-Projectors.** Catalog E-20, 16 pages, illustrates and describes various types of micro-projectors. A price list covers projectors and accessories. Bausch & Lomb Optical Co., 615 St. Paul St., Rochester, N. Y.

D87 **Combination Draft Gage and Flue Gas Temperature Indicator.** Bulletin No. 33-B. 2 pages. This leaflet illustrates and describes two pointer and three pointer indicators and recorders for draft, pressure and flue gas temperature. Defender Automatic Regulator Co., St. Louis, Mo.

D88 **Photoelectric Colorimeter.** 4-page folder covers the operation of this colorimeter designed by Dr. B. Lange. A diagram of its operation is included. Pfaltz & Bauer, Inc., 300 Pearl St., New York City.

D89 **Automatic Reset Timing Relay.** Leaflet lists various types of timing relays. Zenith Electric Co., Inc., 607 S. Dearborn St., Chicago, Ill.

D90 **Sling Psychrometer.** Bulletin S illustrates 2 styles of sling psychrometer. A price list is included. A relative humidity table with directions for its use is also given. Julien P. Friez & Sons, Inc., Baltimore, Md.

D91 **Bearing Thermometer.** 4-page letter size folder describes the "Tel Temp." Application photographs showing applications in various industries are included. These photographs show how the device is used to indicate temperatures on open and closed motors, generators, bus-bars, pump bearings and condensate pumps. Ideal Commutator Dresser Co., Sycamore, Ill.

D92 **Electric Alternators.** Leaflet gives a wiring diagram for an alternator actuated by any type of pilot switch, including float, pressure, push-button, and photo-electric relay. Enterprise Foundry Corp., 2900 19th St., San Francisco, Calif.

D93 **Mercury Tube Toggle Switch.** Leaflet illustrates Catalog No. 6001 T toggle switch and a.c. or d.c., 30 amperes — 125 volts or 20 amperes — 250 volts. Hart Mfg. Co., Hartford, Conn.

D94 **Ohmite News.** The December issue illustrates various forms of rheostats. The January issue covers vitreous enameled resistors. Ohmite Mfg. Co., 4835 Flournoy St., Chicago, Ill.

D95 **Coil and Condenser Analyzer.** Form CC-1 illustrates the Stromberg coil and condenser analyzer for testing coils and condensers. Dimensions and prices are given. Stromberg Motoscope Corp., 2130 Lawrence Ave., Chicago, Ill. Motoscope C, which is a larger model of the same type instrument, is covered in a separate leaflet.

D96 **Hydrometer.** Leaflet covers the Thermotron which is a specially designed hydrometer and a thermometer, upon which are both Fahrenheit and A.P.I. readers. Stromberg Motoscope Corp., 2130 Lawrence Ave., Chicago, Ill.

D97 **Solenoid Valves.** Bulletin 800, 24 pages and cover, describe solenoid operated valves for the automatic and remote control of air, gas, steam and liquids. Automatic Switch Co., 154 Grand St., New York City.

D98 **Volume Controls,** Fixed and Adjustable Resistors. 18 pages and cover. Describes and gives specifications for volume and tone controls as well as for vitreous enameled resistors, adjustable resistors, and power rheostats. Industrial and special resistors are also illustrated. Electrad, Inc., 175 Varick St., New York, N. Y.

D99 **Draft Regulator.** Bulletin DDA-3, 4 pages. Illustrates the furnace draft regulator and shows the proper method of mounting by means of diagrams. Defender Automatic Regulator Co., St. Louis, Mo.

D100 **Muck and Marl Sampler.** Bulletin No. 23 describes a device for locating and determining the extent of muck and marl deposits. Robey Mfg. Co., East Lansing, Mich.

D101 **Seismo-Damper.** Leaflet illustrates this unit and inexpensive isolation of machinery. Korfund Co., Inc., 48-15 32nd Place, Long Island City, N. Y.

D102 **Liquid Meter.** Form 140 illustrates the Empire measurmatic meters and the Microset meter for gasoline and oil trucks. National Meter Co., 4207 First Ave., Brooklyn, N. Y.

D103 **Chemical Measuring Pump.** GD-450 gives engineering data and capacities for a measuring pump. Operating instructions are also included. McCord Radiator & Mfg. Co., Detroit, Mich.

D104 **Continuous Weighing Machines.** Page F-7 illustrates a machine for feeding material at a desired weight per unit of time. Syntron Co., 400 N. Lexington Ave., Pittsburgh, Pa.

D105 **Safety Shut-Off Gas Regulators.** Leaflet gives the construction features of the type No. 10K, 10L gas regulators and the type 57 pressure regulator. Fisher - Governor Co., Marshalltown, Iowa.

D106 **Electrical Tachometers.** Bulletin 935 covers the applications and special features of these indicating and recording tachometers. Esterline-Angus Co., Indianapolis, Ind.

D107 **Color Matching Device.** 4-page bulletin describing a device for use in analyzing color. M-R-H Labs., Dowagiac, Mich.

D108 **Nalco Colorimetric Testing Kits.** Leaflet illustrates the oxygen kit and the silica and phosphate kit. Prices are included. National Aluminate Corp., 6216 W. 66th Place, Chicago, Ill.

D109 **Light Meter.** 4-page folder SL-1 covers the salient features of the light indicator developed by the Sight Light Corp., 342 Madison Ave., New York City.

INSTRUMENTS' BOOK SHELF

Continued from page 81

Industrial Electronics. By F. H. Gulliksen and E. H. Vedder. John Wiley & Sons, Inc., New York. Cloth, 6 x 9¼ inches, 245 pages. Price $3.50.

This excellent non-mathematical treatment of electronic devices and their applications in industry appears at a time when the electron tube and its associated circuits are daily finding new and important uses in industrial practices. The opening chapters deal with electronic tubes in a novel but logical sequence, dividing them into three groups: light-sensitive, high-vacuum, and gaseous; and each of these groups is again classified according to operating principles. Instead of treating photoelectric cells as a more or less incidental appendage to the general subject to electronic devices, the book opens with a chapter on phototubes, including selenium cells and photovoltaic cells. High-vacuum tubes are briefly described as to their general features, the discussion being carried to the extent of touching upon cathode-ray oscillograph tubes and X-ray tubes. Under gas-filled tubes are treated the various rectifying and grid-glow tubes, including mercury-pool tubes and gas-filled lamps. "When a standardized name is not available for a particular type of tube a Westinghouse trade name is used."

The second part deals with fundamental electronic circuits, those for the three classes of tubes being discussed separately to illustrate more clearly the various forms of control obtainable. Among the typical circuits are treated oscillating systems, trigger control, phase-shift control, multiphase control, and "Ignitron" circuits.

In the third section are introduced electronic measuring and controlling instruments, pointing out the fundamental advantages of practically instantaneous action, low energy consumption from the primary source, and the ability to operate an unlimited number of times without mechanical wear.

Included among light-sensitive control devices will be found many typical applications, such as color selection, counting, door-openers, elevator levelling and protection, and the control of artificial lighting. A chapter on Indicating and Recording Devices, dealing with applications of electron tubes to quantitative measurement, opens with the significant statement that "Most electronic instruments use 'null' or comparison methods which cancel out all tube characteristics from the calibration of the instrument." There are described, however, several photometric instruments in which the tube characteristics enter directly into the measurement. Smoke recorders for steam power plants are among the subjects here treated in some detail. It is noted that in the discussion of electronic recorders one type and make using thermionic tubes receives considerable attention, while a contemporary and competitive instrument using photocells is not mentioned. Under quantitative measurements using phototubes are discussed measurement of transmittency and color matching. Some circuits of the cathode-ray oscillograph are treated.

The authors recognize only two classes of telemetering — current and impulse—, and describe the use of electronic tubes in the former only, without regard to the fact that all five recognized classes of telemetering systems may make use of electronic tubes, descriptions of a number of these having appeared in current technical literature. The use of stroboscopic lamps in the study of rapidly moving mechanisms, in speed determination, and in the calibration of meters is touched upon. Thorough consideration is given to rectifiers, small and large, showing a variety of circuits and including the use of the Ignitron as a power rectifier. Electronic inverters are briefly treated, there being pointed out a number of present-day obstacles to their universal use.

Among other subjects of practical interest which receive consideration may be mentioned the control and timing of welders, high-voltage rectifiers for electrolytic precipitation of solids from gases, industrial X-rays and the **Theory of Alternating Current Waveductivity** in the control of oil burners. study of crystal structures, the control of theater and mobile lighting, including the use of saturable-cored reactors, and the utilization of flame con-

Under the heading of Electronic Relays are treated synchronizing devices, time relays, and protective relays of various types. A chapter on Automatic Regulation is introduced by a timely discussion of the essentials of automatic regulators, leading up to the outstanding features of the electronic circuit in this field. Seven types of voltage regulating circuits are described, particular attention being given to antihunting methods, speed control, frequency control, the regulation of tension in various types of winding and rolling machines, and printing register control, as in the manufacture of bags, are discussed. Process regulators based on color or other physical properties of the processed material occupy a chapter, and the work closes with a brief chapter on the subject of Temperature Regulators.

This book provides an acceptable cross-section of the application of electronic tubes and circuits to industrial purposes; and while it is manifestly far from complete, the essential principles of practically every important industrial use of electronic methods will be found described in some form.

The volume is well illustrated (245 figs.). Two opening pages are devoted to symbols used in the diagrams throughout the work; and these diagrams are consistent, clear and easy to interpret. There are also many reproductions of photographs. More than 130 bibliographical references are distributed as footings to the chapters—not as identifiable footnotes; so that the reader has to guess which source to look up in order to study any topic briefly touched upon in the chapter. Only in this one respect can the book be said to be defective. Though there appear some expressions hardly consistent with the ideals of the purist in technical literature, yet the text is generally characterized by great clarity and directness.

Because of the complete elimination of mathematical discussions, and because of not being burdened with communication apparatus and circuits, this work, though showing a decided leaning to the products of one manufacturer, should be widely and profitably read by engineers in the power and industrial fields, as well as by students of industrial control. The authors' statements—"The book will be helpful to practicing engineers in showing ways in which electronic apparatus may prove useful to them" and "A very interesting and useful course on industrial electronic apparatus can be presented using this book as the main text or to supplement a more fundamental course of study on electronic tubes"—appear to be well justified.

Perry A. Borden (5.4)-B-

"*f*"—the Pipe Line Flow Factor. Part II. By Forrest M. Towl. Published by the Author. New York, 1935. Paper, 6x9 inches, 20 pages + sheet of corrections for Part I. Intended for distribution to those who already have a copy of Part I.

The distinguished veteran engineer's Part I was reviewed in our December 1934 issue, page 272. It covered the flow of liquids through pipe lines. This addendum considers in like manner the flow of air and gases through pipe lines. Again the author harks back for a starting point to his pamphlet published in 1889 and reprinted in 1910; and again a reviewer belonging to the so-called modern generation is interested to note how refreshingly new the Towl unitary scheme appears. Although equation (III) is now written

$$\frac{h}{f} = \frac{v^2 l}{2gd}$$

with the right hand side containing "all the factors which measure the volume of the flow" as well as the gravity factor which of course is constant for any locality, it is still the same unitary scheme with f a dimensionless number. Most of Part II is devoted to reports of tests actually made —not in the laboratory but on a pipe line—which seem to prove the validity and practicality of the author's method.

Forms. By Philip Kemp. Instruments Publishing Co., Pittsburgh, 1935. Cloth, 5½x8¾ inches, viii + 218 pages. Price $4.50 postage prepaid.

This book deals with an extremely important part of electrical engineering and one in which a new book dealing with the fundamentals would be very welcome. In the ordinary treatment of electrical machinery, such as is given in the usual technical school, simple theories are developed which depend essentially upon all alternating quantities being of sinusoidal form. In actual practice this sinusoidal form is never attained and even where it is approximately obtained, as in the terminal voltage of generators, it is not at all obtained in the constituent parts of electrical devices. Also the inherent nature of the commonly used magnetic material, iron, is such that simultaneous sinusoidal forms of currents and voltages are impossible.

With the need of a good text in this field so great, it is disappointing to find the offered volume so deficient in many ways. The choice of subject matter in the volume seems to the reviewer to be very poor. Not enough space is given to the careful definition and explanation of the mathematical theorems involving the expression of a periodic function into a series of sinusoidal terms. Altogether too much space is devoted to the treatment of extremely simple circuits which are calculated in great detail and unjustified numerical profusion considering the simplicity of such problems. On the other hand, the effect of non-sinusoidal currents and voltages upon rotating machines is barely mentioned. The importance of harmonics in connection with rectifiers and rotary converters receives scant mention. The influence of the nature of windings of machines upon harmonics receives almost no treatment. In the theory of polyphase circuits the nature of the phase sequence of the harmonics, a most important characteristic, is not mentioned.

Worse than all of these deficiencies, the book is so full of errors and incomplete and misleading statements as to be absolutely detrimental in the example it sets to the immature student and to create a great mistrust of the book as a reference source to mature students. Following is a list of the obvious errors and mis-statements which the reviewer was able to find by a hurried reading of the book. Undoubtedly, there are numerous others:—

Chapter I, page 1—It is stated that in the usual forms of electro-magnetic machinery the even harmonics are all absent. This seems to shut out rectifiers and rotary converters as usual forms of electro-magnetic machinery. It overlooks the fact that even harmonics are practically always present in the field circuits of synchronous machines and in the damping windings of synchronous machines. In single phase machines and polyphase machines, under unbalanced conditions these even harmonics are very large.

Again on page 1, the phase angle of a harmonic is incompletely and probably incorrectly defined. The definition of a harmonic in phase with the fundamental is ambiguous for even harmonics. The angle which a harmonic may be behind this "in phase" position is defined as the phase of the harmonic but whether this angle is measured in electrical degrees of the fundamental or of the harmonic is not mentioned. From the text on page 2 and following, it appears that this angle is to be measured in electrical degrees of the fundamental but in later pages electrical degrees of the harmonic is chosen. The ambiguity in the phase angle of the harmonic arising from the former definition is not mentioned. Thus in Fig. 1, the beginner would not realize that the phase angle $\alpha = 135°$ gives the same wave as $\alpha = 15°$.

On page 7 in the paragraph on "Harmonic Interference," the statement that the sum of the two harmonics is equal to a harmonic of intermediate order, even with the proviso that this harmonic is of varying amplitude, is certainly stretching the meaning of the harmonic to an impossible limit and upsets the important notion which the beginner should acquire of the unique-

M. F. Béhar (2.05)-B-

ness of the representation of periodic quantities in a series of harmonics.

On page 12, the reactance of an inductor for non-sinusoidal quantities is not defined. One needs to discover by later reading that the ratio of the r.m.s. voltage to the r.m.s. current of the inductor is meant and then to discover that this ratio may have so variable a value as to make the term "reactance" cease to have any valuable meaning.

On page 19 paragraph "Advantage of Sine Wave," maximum and minimum properties of the sine wave are given without specifying what factors are kept constant as is always necessary in any maximum or minimum proposition.

Pages 19 to 46 deal with simple series circuits at tedious lengths. No intimation is given that such simple circuits are not typical of what is obtained in practice. For example, the induction motor, while presenting to the fundamental component of voltage an impedance equivalent to a resistance and a reactance in series and also impedance of the same form to the higher harmonics, nevertheless the impedances to the higher harmonics are not obtained from that for the fundamental by the formulae given in these pages.

To exemplify the lack of meaning of the reactance to complex wave forms which the author discusses and the inconsistencies to which he is driven, we may point to page 22 at the top where a 20% third harmonic in the voltage gives a 2.62% increase in the reactance, whereas in the table on page 13, a 20% third harmonic in the voltage on the reactor alone gives only 1.76% increase in the reactance.

On page 29, the definition of resonating frequency in a circuit is most extraordinary. At this resonating frequency the power factor is not 100% and the resonating frequency has no correspondence to the natural frequencies of the circuit. In fact the resonating frequency defined here is a function of the applied voltage as well as of the circuit constants and may be made any value one pleases by choosing a suitable wave form.

In Chapter II, page 49, power factor is defined with no intimation that the meaning of power factor under non-sinusoidal conditions has been much debated and no universally accepted definition has been arrived at. It is most likely that a single power factor will not prove useful and the one defined by the author will have value only for limited types of calculation.

On this same page the suggestion to reduce the amplitude of the equivalent current wave to fit the power factor is most astounding, as the equivalent sine wave of current had been previously defined as one having the same r.m.s. value as the given wave.

On page 54, the section on "Harmonic Imitation" violates the fundamental mathematical principle of the uniqueness of a Fourier expansion. It is of absolute importance that the harmonics corresponding to a given wave shall be uniquely defined. Without such uniqueness the whole theory of harmonics falls down. For example if on page 55, the third harmonic can be written as a sum of other harmonics then we may, if we choose, eliminate the third harmonic from the expansion of a wave by means of the equation on page 55 and the given wave has or has not a third harmonic as we choose. In fact by the equation on page 55, if it has any validity, we can make the third harmonic of any wave any value we please. So fundamental an error as appears in this short paragraph is sufficient in the reviewer's mind to discredit the whole book.

On page 64, the form factor is defined as the ratio of the r.m.s. to the average value of the wave taken over a *complete* cycle. For all waves having no d.c. component the average value of a complete cycle is zero. The author probably meant the average of the absolute value of the wave taken over the complete cycle.

On page 65, the introduction of $\pm$ signs seems to be both unnecessary and very confusing. The same applies to equation 75 on page 70.

On page 72, the expression that the harmonics become damped down is very erroneous in its connotation and actual meaning. The subsequent calculations show that the amplitude of a harmonic is not multiplied by an exponential function of the angular differences in the position of two conductors but by a trigonometric function which does not correspond to what we usually mean by damping.

On page 77, the paragraph on "Wave Filter," the first sentence is certainly not true generally. In the next paragraph, first sentence, the meaning of resonating circuit is different from that used on page 29. Fig. 29 gives the wrong principle for making a wave filter for suppressing harmonic voltages at least as explained at the bottom of page 77.

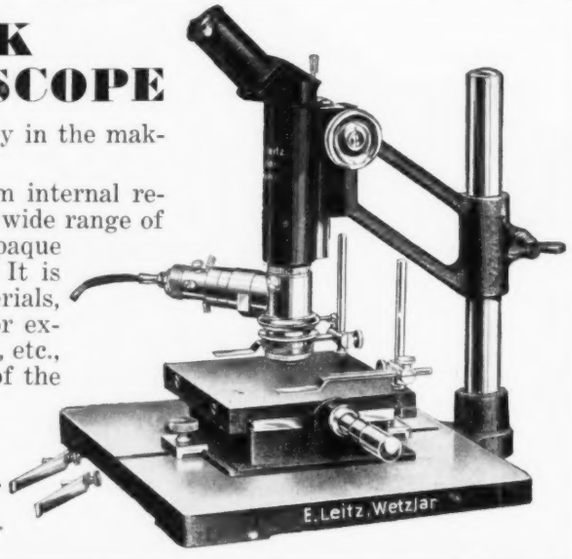
In Chapter III, page 107, the table, the harmonics in the magnetizing current of stalloy plates are given as strictly zero up to an induction of 10,000. Actually the harmonics are quite large at all inductions.

On page 109, beginning of paragraph on "Origin of Third Harmonic," the opening sentence seems to the reviewer to be not only incorrect but nonsensible. The whole material of this and the following paragraph seems to

LEITZ ULTROPAK MEASURING MICROSCOPE

This instrument combines simplicity with flexibility in the making of accurate measurements.

Uniformity of illumination, complete freedom from internal reflection, adaptation to the nature of the object and wide range of magnification make the ULTROPAK ideal for all opaque and semi-opaque objects of low reflecting power. It is suitable for examination of a wide variety of materials, surfaces, tools, etc., and can be readily adapted for examination of inside surfaces of cylinders, drill holes, etc., without the necessity of preliminary preparation of the objects.



E. LEITZ, INC., Dept. X
60 EAST TENTH STREET, NEW YORK, N. Y.
Branches:
WASHINGTON, D. C. CHICAGO, ILLINOIS SAN FRANCISCO, CALIF. LOS ANGELES, CALIF.

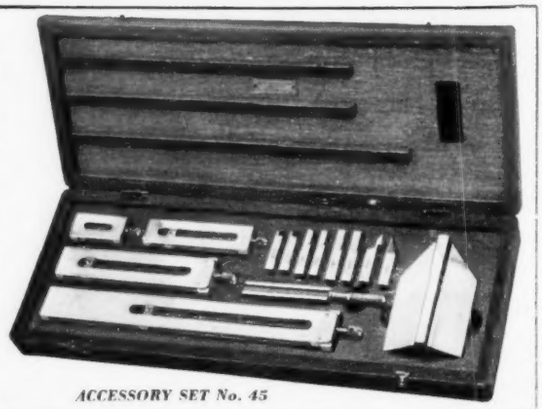
ACCESSORIES
THAT GREATLY INCREASE THE USEFULNESS OF
JOHANSSON GAGE BLOCKS

JAWS ADJUSTABLE HOLDERS SCRIBERS
CENTER POINTS TRAM POINTS FOOT BLOCKS
TRIANGULAR STRAIGHT EDGES SINE BARS

Sold individually or in sets. Write for Catalog No. 11.

Manufactured, sold and serviced in the United States and Canada by

FORD MOTOR COMPANY
Johansson Division **Dearborn, Michigan**



ACCESSORY SET No. 45

the reviewer to be without any meaning. Similarly the reviewer cannot find any serious meaning in the paragraph on "Separation of Permeability and Hysteresis Effects," page 115.

On page 126, the last paragraph of the chapter, the fact that displaced hysteresis loops may be obtained in the absence of d.c. component in magnetizing current is not recognized. In fact a displaced loop is always obtained when even harmonics are present in the impressed voltage wave and may be obtained with sinusoidal voltage wave depending upon the previous history of the iron.

On page 143, the treatment of the inductive action in coils whose magnetic circuits containing iron are varied periodically by motion of the iron, is fundamentally incorrect and the equation 158 is wrong. For example according to equation 158, if direct current flows in the coil the reactance "X" would be zero and no voltage would be induced in the coil. However, it is quite clear from fundamental principles that alternating voltage would be induced in such a coil with a periodicity equal to that of the motion of the iron.

On page 153, paragraph on "Oscillating Neutral," an insulated star point is first spoken of and then in the next sentence we find the "line conductors anchored to earth by being earthed at some other point, probably the generator in the power station." How a system can be both insulated from earth and grounded to earth at the same time is beyond the power of understanding of the reviewer.

On page 154, the first sentence of the paragraph is also meaningless to the reviewer, since if the voltages of line to earth are all sinusoidal, he cannot see how the third harmonic can creep into the voltage between the lines and any other plausible point.

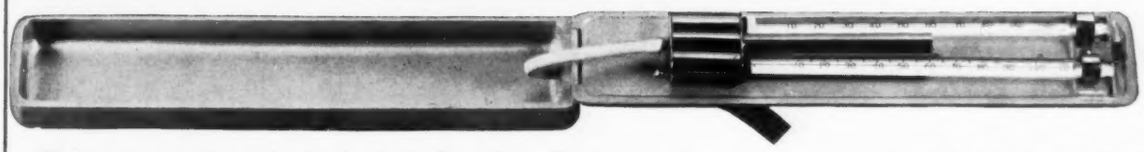
The errors cited above must not be taken to be at all exhaustive but are merely those which thrust themselves upon the reviewer's attention as he rapidly scanned through the book.

JOSEPH SLEPIAN (4)-B-

ADVERTISERS' INDEX

	Page
Accurate Instrument Company	A10
American Meter Company	65
Bailey Meter Company	60
Baldwin-Southwark Corp.	Inside back cover
Bausch & Lomb Optical Company	A2
Bristol Company	Back cover
Brown Instrument Co.	A5
Chace Valve Co., W. M.	A10
Clifford Mfg. Company	61
Cochrane Corporation	65
Continental Electric Company	66
Eppley Laboratory, Inc.	A7
Federal Products Corp.	A9
Ferranti Electric, Inc.	A7
Ford Motor Co., Johansson Div.	88
Foxboro Company	Inside front cover
Friez & Sons, Julien P.	89
Gaertner Scientific Corp.	A7
General Plate Company	66
General Radio Company	A7
Gordon Co., Claud S.	A8
G-M Laboratories, Inc.	62
Hays Corporation	67
Illinois Testing Labs., Inc.	84
Johansson Gage Div., Ford Motor Co.	88
Kurman Electric Company	67
Leeds & Northrup Company	A6
Leitz, Inc., E.	88
Littelfuse Laboratories	90
Minneapolis-Honeywell Regulator Co.	A5
Pioneer Instrument Co.	63
Pyrometer Instrument Co.	68
Rawson Electrical Instrument Co.	82
RCA Manufacturing Co., Inc.	A9
Review of Scientific Instruments	Inside back cover
Riehle Div., American Machine & Metals Mfg. Corp.	64
Roller-Smith Company	82
Rubicon Company	83
Shallcross Mfg. Co.	83
Slip-Lens Company	A10
Taylor Instrument Companies	A3
Triplett Electrical Instrument Co.	A9
Trofimov School of Inventive Practice	84
Ward Leonard Electric Co.	A9
Weston Electrical Instrument Corp.	A1
Winslow Engineering Co.	84

IMPROVED HUMIDITY MEASUREMENT



- **A stream of typical air is *induced* to flow across the thermometers bulbs by means of a venturi, pressure for which is supplied by a combination rubber bulb and reservoir. *There is no whirling.***
- **Stationary thermo-shielded thermometers are under *continuous observation* while the wet-bulb reaches its low temperature point.**
- ***Highest accuracy* is attained and without need of special technique.**
- **A *pocket-size* instrument of great value, that can be used inconspicuously in public places and conveniently in crowded rooms.**

PRICE $15.00 AT BALTIMORE

Made exclusively by

JULIEN P. FRIEZ & SONS, Inc.

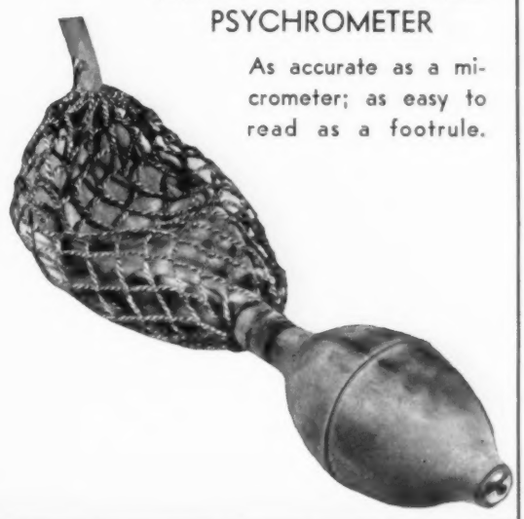
(A subsidiary of the Bendix Aviation Corporation)

BALTIMORE, MARYLAND

"THE MAKERS OF AMERICA'S WEATHER INSTRUMENTS"

FRIEZ HAND ASPIRATED PSYCHROMETER

As accurate as a micrometer; as easy to read as a footrule.



BUYERS' GUIDE

to Devices for Measurement, Inspection, Testing or Control

If you are unable to find what you require in this section of INSTRUMENTS, write Information Section, Instruments Publishing Company. Give complete information of requirements.

Note: This MONTHLY guide lists the products of our advertisers; the ANNUAL Instruments Index sent to subscribers lists the products of more than 800 manufacturers.

ACCELEROMETERS
General Electric Co.

AIR METERS
American Meter Co.
Bailey Meter Co.
Bristol Co.
Brown Instrument Co.
Foxboro Co.
Friez & Sons, Inc.
Pioneer Instrument Co.
Taylor Instruments Cos.

ALTIMETERS
Friez & Sons, Inc.
General Electric Co.
Pioneer Instrument Co.
Taylor Instrument Cos.

ALTITUDE BAROMETER
Bristol Co.
Friez & Sons, Inc.
Taylor Instrument Cos.

AMMETERS—Indicating
General Electric Co.
Rawson Elec. Co.
Roller-Smith Co.
Triplett Elec. Inst. Co.
Westinghouse E. & M.Co.
Weston Elec. Inst. Corp.

Recording
Bristol Co.
Brown Instrument Co.
General Electric Co.
Leeds & Northrup Co.
Roller-Smith Co.
Westinghouse E. & M.Co.

ANEMOMETERS
Bristol Co.
Friez & Sons, Inc.
Taylor Instrument Cos.

ARCRONOGRAPHS
Rubicon Co.

ASPHALT TESTING APPARATUS
Baldwin-Southwark Corp.
Taylor Instrument Cos.

ASTRONOMICAL INSTRUMENTS
Bausch & Lomb Opt. Co.
Gaertner Scientific Corp.

BALANCES
Roller-Smith Co.

BALANCING MACHINES
General Electric Co.

BAROMETERS
Bristol Co.
Friez & Sons, Inc.
Gaertner Scientific Corp.
Pioneer Instrument Co.
Taylor Instrument Cos.

BATTERY TESTERS
Roller-Smith Co.
Triplett Elec. Inst. Co.
Westinghouse E. & M.Co.
Weston Elec. Inst. Corp.

BELLOWS
Clifford Mfg. Co.

BIMETAL ELEMENTS
W. M. Chace Co.

BOARDS: INSTRUMENT
Bailey Meter Co.
Bristol Co.
Brown Instrument Co.
Cochrane Corp.
Foxboro Co.
Friez & Sons, Inc.
General Electric Co.
Rubicon Co.
Taylor Instrument Cos.
Westinghouse E. & M.Co.

BOILER METERS
American Meter Co.
Bailey Meter Co.
Brown Instrument Co.
Cochrane Corp.
Foxboro Co.

BRAKETESTING METERS
Kurman Electric Co.
Rawson Elec. Inst. Co.

BRIDGES, ELECTRICAL
Capacity, Inductance, Kelvin Resistance, Temperature, Wheatstone, Percent
Bristol Co.
Eppley Lab., Inc.
General Electric Co.
General Radio Co.
Leeds & Northrup Co.
Roller-Smith Co.
Rubicon Co.
Shallcross Mfg. Co.
Triplett Elec. Inst. Co.

CABLE TESTERS
Kurman Electric Co.
Leeds & Northrup Co.
Rawson Elec. Inst. Co.
Roller-Smith Co.

CALORIMETERS
American Meter Co.
Gaertner Scientific Corp.

CALIPERS, DIAL
Federal Products Corp.

CAMERAS—HIGH SPEED
General Radio Co

CAPACITANCE METERS
General Electric Co.
General Radio Co.
Leeds & Northrup Co.
Roller-Smith Co.
Rubicon Co.
Triplett Elec. Inst. Co.
Weston Elec. Inst. Corp.

CARBON DIOXIDE METERS
Brown Instrument Co.
Foxboro Co.
Leeds & Northrup Co.

CATHETOMETERS
Gaertner Scientific Corp.

CENTER POINTS
Ford Motor Co.

CHRONOGRAPHS AND CHRONOMETERS
Gaertner Scientific Corp.
General Electric Co.
General Radio Co.

CLINOMETERS
Pioneer Instrument Co.

CLOCKS—Gage Board
Bailey Meter Co.
Bristol Co.
Brown Instrument Co.
Foxboro Co.
Pioneer Instrument Co.

COILS
Resistance, Inductance, Special
General Electric Co.
General Radio Co.
Leeds & Northrup Co.
Roller-Smith Co.
Rubicon Co.
Shallcross Mfg. Co.
Ward Leonard Elec. Co.
Westinghouse E. & M.Co.

COIL TESTING EQUIPMENTS
General Electric Co.
Kurman Electric Co.
Leeds & Northrup Co.
Roller-Smith Co.
Rubicon Co.
Westinghouse E. & M.Co.

COLORIMETERS
Bausch & Lomb Opt. Co.
Gaertner Scientific Corp.
General Electric Co.

COMBUSTION CONTROLS —See Controls

COMMUNICATION MEASURING INSTRUMENTS
General Radio Co.
Kurman Electric Co.
Leeds & Northrup Co.
Rawson Elec. Inst. Co.
Roller-Smith Co.
Rubicon Co.
Shallcross Mfg. Co.
Triplett Elec. Inst. Co.
Westinghouse E. & M.Co.

COMPARATORS
Federal Products Corp.
Gaertner Scientific Corp.
General Electric Co.

COMPASSES
Pioneer Instrument Co.
Taylor Instrument Cos.

CONDENSERS—Electrical
General Electric Co.
General Radio Co.
Leeds & Northrup Co.
Rubicon Co.
Westinghouse E. & M.Co.

CONDUCTIVITY METERS
Indicating, Recording, Controlling
Kurman Electric Co.
Leeds & Northrup Co.
Rawson Elec. Inst. Co.
Roller-Smith Co.
Rubicon Co.
Shallcross Mfg. Co.

CONTOUR MEASURING PROJECTOR
Bausch & Lomb Opt. Co.
E. Leitz, Inc.

CONTROLS, AUTOMATIC
Air Conditioning
Brown Instrument Co.
Powers Regulator Co.

Air Velocity
Powers Regulator Co.

Burner
Brown Instrument Co.

Combustion
Bailey Meter Co.
Bristol Co.
Brown Instrument Co.
Foxboro Co.
Leeds & Northrup Co.
Pioneer Instrument Co.

Condensation
Bristol Co.
Foxboro Co.
Friez & Sons, Inc.
Taylor Instrument Cos.

Damper
Bailey Meter Co.
Bristol Co.
Brown Instrument Co.
Foxboro Co.
Friez & Sons, Inc.
Johnson Service Co.
Leeds & Northrup Co.
Powers Regulator Co.
Taylor Instrument Cos.
Wilbin Instrument Co.

Dial
Automatic Electric Co.

Feed Water
American Meter Co.
Bailey Meter Co.
Bristol Co.
Brown Instrument Co.
Foxboro Co.

Flow
American Meter Co.
Bailey Meter Co.
Bristol Co.
Brown Instrument Co.
Cochrane Corp.
Foxboro Co.
Taylor Instrument Cos.

Humidity
Bristol Co.
Brown Instrument Co.
Foxboro Co.
Friez & Sons, Inc.
Johnson Service Co.
Powers Regulator Co.
Taylor Instrument Cos.

Humidity & Temperature
Bristol Co.
Brown Instrument Co.
Foxboro Co.
Friez & Sons, Inc.
Johnson Service Co.
Powers Regulator Co.
Taylor Instrument Cos.

Humidity—Time
Friez & Sons, Inc.

Lighting
General Electric Co.
Westinghouse E. & M.Co.
Weston Elec. Inst. Corp.

Liquid Level
American Meter Co.
Bailey Meter Co.
Bristol Co.
Brown Instrument Co.
Cochrane Corp.
Foxboro Co.
Friez & Sons, Inc.
General Electric Co.
Leeds & Northrup Co.
Powers Regulator Co.
Taylor Instrument Cos.

Moisture-content
Powers Regulator Co.

Pressure & Vacuum
American Meter Co.
Bailey Meter Co.
Bristol Co.
Brown Instrument Co.
Cochrane Corp.
Continental Elec. Co.
Foxboro Co.
Powers Regulator Co.
Taylor Instrument Cos.

Pyrometer
Bailey Meter Co.
Bristol Co.
Brown Instrument Co.
Foxboro Co.
Leeds & Northrup Co.
Taylor Instrument Cos.

Rate-Volume
American Meter Co.
Cochrane Corp.
Foxboro Co.

Refrigeration
Bristol Co.
Brown Instrument Co.
Foxboro Co.
Friez & Sons, Inc.
Johnson Service Co.
Powers Regulator Co.
Taylor Instrument Cos.

Specific Gravity
Bailey Meter Co.
Foxboro Co.

Tachometer
Bailey Meter Co.
Bristol Co.
Brown Instrument Co.
Foxboro Co.
Leeds & Northrup Co.
Westinghouse E. & M.Co.
Weston Elec. Inst. Corp.

Temperature
Bailey Meter Co.
Bristol Co.
Brown Instrument Co.
Cochrane Corp.
Foxboro Co.
Friez & Sons, Inc.
Leeds & Northrup Co.
Powers Regulator Co.
Taylor Instrument Cos.

Temperature-Time
Bailey Meter Co.
Bristol Co.
Brown Instrument Co.
Foxboro Co.
Friez & Sons, Inc.
Johnson Service Co.
Leeds & Northrup Co.
Powers Regulator Co.
Taylor Instrument Cos.

Time
Bristol Co.
Brown Instrument Co.
Foxboro Co.
Friez & Sons, Inc.
General Electric Co.
Johnson Service Co.
Powers Regulator Co.
Taylor Instrument Cos.
Ward Leonard Elec. Co.

Vacuum
Bailey Meter Co.
Bristol Co.
Brown Instrument Co.
Cochrane Corp.
Continental Elec. Co.
Foxboro Co.
Powers Regulator Co.
Taylor Instrument Cos.

Valve—Motor-Operated
Bailey Meter Co.
Bristol Co.
Brown Instrument Co.
Foxboro Co.
Leeds & Northrup Co.
Powers Regulator Co.
Taylor Instrument Cos.

Voltage A. C.
Ward Leonard Elec. Co.

COUNTERS—Magnetic
Ward Leonard Elec. Co.

Revolution
Bristol Co.
Brown Instrument Co.

Stroke
Bristol Co.

CUBIC FOOT BOTTLES
American Meter Co.

CURRENT RECORDERS
Bristol Co.
General Electric Co.
Leeds & Northrup Co.
Roller-Smith Co.

CYCLE CONTROLLERS
Bristol Co.
Foxboro Co.
Taylor Instrument Cos.

CYCLE COUNTERS
General Radio Co.
Westinghouse E. & M.Co.

CYCLE RECORDERS
General Electric Co.

CYLINDER GAGES
Federal Products Corp.

DAMPERS
Powers Regulator Co.

DEMAND METERS
Gas
Foxboro Co.
Electric: Indicating, Recording, Printing
General Electric Co.
Westinghouse E. & M.Co.

DEPTH GAGES
Federal Products Corp.

DIAL INDICATORS
Federal Products Corp.

DIVIDING MACHINES
Gaertner Scientific Corp.

DRAFT GAGES—See Gages

DYNAMOMETERS
General Electric Co.
Kurman Electric Co.
Rawson Elec. Inst. Co.
Leeds & Northrup Co.
Weston Elec. Inst. Corp.

EARTH CURRENT METERS
Kurman Electric Co.
Leeds & Northrup Co.
Rawson Elec. Inst. Co.
Roller-Smith Co.

ELECTRIC TELEMETERS —See Remote Metering Equipment

ELECTRONIC METERS
General Electric Co.
General Radio Co.
Kurman Electric Co.
Leeds & Northrup Co.
Rawson Elec. Inst. Co.
Westinghouse E. & M.Co.
Weston Elec. Inst. Corp.

EXTENSOMETERS
Baldwin-Southwark Corp.
Riehle Div. Am. Mach.

FAULT FINDERS
Leeds & Northrup Co.
Roller-Smith Co.
Rubicon Co.
Shallcross Mfg. Co.
Westinghouse E. & M.Co.

FLASH & BURNING POINT TESTERS
Taylor Instrument Cos.

FLOW METERS
Indicating
Bailey Meter Co.
Bristol Co.
Brown Instrument Co.
Cochrane Corp.
Foxboro Co.
Friez & Sons, Inc.
Pioneer Instrument Co.
Taylor Instrument Cos.

Indicating & Recording
American Meter Co.
Bailey Meter Co.
Bristol Co.
Brown Instrument Co.
Cochrane Corp.
Foxboro Co.
Friez & Sons, Inc.
Pioneer Instrument Co.
Taylor Instrument Cos.

Integrating & Recording
American Meter Co.
Bailey Meter Co.
Bristol Co.
Cochrane Corp.
Brown Instrument Co.
Foxboro Co.
Taylor Instrument Cos.

FLUE GAS ANALYZERS
Brown Instrument Co.
Foxboro Co.
Leeds & Northrup Co.

FLUXMETERS
Kurman Electric Co.
Leeds & Northrup Co.
Rawson Elec. Inst. Co.
Rubicon Co.

FOOT CANDLE METERS
General Electric Co.
Westinghouse E. & M.Co.
Weston Elec. Inst. Corp.

FREQUENCY METERS
Indicating
Bristol Co.
General Electric Co.
Leeds & Northrup Co.
Roller-Smith Co.
Westinghouse E. & M.Co.
Weston Elec. Inst. Corp.

Recording
Bristol Co.
General Electric Co.
Leeds & Northrup Co.
Westinghouse E. & M.Co.

Standards
General Radio Co.
Leeds & Northrup Co.

FRITTED GLASS
Fish-Schurman Corp.

FURNACE CONTROLS
Bailey Meter Co.
Bristol Co.
Foxboro Co.
Friez & Sons, Inc.
Leeds & Northrup Co.
Taylor Instrument Cos.

GAGES
Absolute Pressure
American Meter Co.
Bailey Meter Co.
Bristol Co.
Brown Instrument Co.
Continental Elec. Co.
Foxboro Co.
Friez & Sons, Inc.
Taylor Instrument Cos.

Caliper
Federal Products Corp.

Cylinder
Federal Products Corp.

Depth
Federal Products Corp.

Dial Indicator
Federal Products Corp.

Differential Pressure
American Meter Co.
Bailey Meter Co.
Bristol Co.
Brown Instrument Co.
Foxboro Co.
Pioneer Instrument Co.
Taylor Instrument Cos.

Draft
Bailey Meter Co.
Bristol Co.
Brown Instrument Co.
Foxboro Co.
Friez & Sons, Inc.

Drill
Bausch & Lomb Opt. Co.

Electric
General Electric Co.

Flow
American Meter Co.
Bailey Meter Co.
Bristol Co.
Brown Instrument Co.
Cochrane Corp.
Foxboro Co.
Friez & Sons, Inc.
Taylor Instrument Cos.

Grinding
Federal Products Corp.

Liquid Level
American Meter Co.
Bailey Meter Co.
Bristol Co.
Brown Instrument Co.
Cochrane Corp.
Foxboro Co.
Friez & Sons, Inc.
Leeds & Northrup Co.
Pioneer Instrument Co.
Taylor Instrument Cos.

Paper Thickness—Continuous
Federal Products Corp.

Precision Measuring
Federal Products Corp.

Pressure
American Meter Co.
Bailey Meter Co.
Baldwin-Southwark Corp.
Bristol Co.
Brown Instrument Co.
Cochrane Corp.
Foxboro Co.
Friez & Sons, Inc.
Taylor Instrument Cos.

Pressure-Temperature
Bailey Meter Co.
Bristol Co.
Brown Instrument Co.
Cochrane Corp.
Foxboro Co.
Taylor Instrument Cos.

Pressure & Vacuum
Bailey Meter Co.
Bristol Co.
Brown Instrument Co.
Cochrane Corp.
Foxboro Co.
Friez & Sons, Inc.
Taylor Instrument Cos.

Rain
Friez & Sons, Inc.
Taylor Instrument Cos.

Recording—Distance
American Meter Co.
Bailey Meter Co.
Bristol Co.
Brown Instrument Co.
Cochrane Corp.
Foxboro Co.
Friez & Sons, Inc.
Leeds & Northrup Co.
Pioneer Instrument Co.
Taylor Instrument Cos.

Strain
Baldwin-Southwark Corp.
General Electric Co.

Vacuum
Continental Elec. Co.
Bristol Co.
Brown Instrument Co.
Foxboro Co.
Friez & Sons, Inc.
General Electric Co.
Taylor Instrument Cos.

Volume
American Meter Co.
Brown Instrument Co.
Foxboro Co.

Wind
Bristol Co.
Brown Instrument Co.
Friez & Sons, Inc.
Taylor Instrument Cos.

Wire
Federal Products Corp.

GAGE BLOCKS
Ford Motor Co.

GALVANOMETERS
American Meter Co.
Brown Instrument Co.
General Electric Co.
Kurman Electric Co.
Leeds & Northrup Co.
Rawson Elec. Inst. Co.
Roller-Smith Co.
Rubicon Corp.
Taylor Instrument Cos.
Triplett Elec. Inst. Co.
Westinghouse E. & M.Co.
Weston Elec. Inst. Corp.

Mirrors
Fish-Schurman Corp.

GAS ANALYTICAL METERS
Chemical
Rubicon Co.
Electrical
Brown Instrument Co.
Leeds & Northrup Co.

GAS FLOW INDICATORS
American Meter Co.
Bailey Meter Co.
Foxboro Co.

GAS LEAK INDICATORS
Pioneer Instrument Co.
Taylor Instrument Cos.

GAS-METERS
American Meter Co.
Bailey Meter Co.
Brown Instrument Co.
Foxboro Co.
Dry Test
American Meter Co.
Foxboro Co.
Wet Test
American Meter Co.
Foxboro Co.

GLASS STRAIN TESTERS
Gaertner Scientific Corp.

GOVERNORS
Pressure
American Meter Co.
Bailey Meter Co.
Bristol Co.
Brown Instrument Co.
Foxboro Co.
Taylor Instrument Cos.
Pump
Bailey Meter Co.
Taylor Instrument Cos.

GRAVITOMETERS
American Meter Co.

GROUND DETECTORS
Roller-Smith Co.
Weston Elec. Inst. Corp.

HARDNESS TESTERS
Baldwin-Southwark Corp.
Riehle Div. Am. Mach.

HIGH FREQUENCY APPARATUS
General Radio Co.
Kurman Electric Co.
Rawson Elec. Inst. Co.
Roller-Smith Co.
Triplett Elec. Inst. Co.
Westinghouse E. & M.Co.
Weston Elec. Inst. Corp.

HIGH VOLTAGE Indicators
Roller-Smith Co.
Shallcross Mfg. Co.
Triplett Elec. Inst. Co.
Westinghouse E. & M.Co.
Weston Elec. Inst. Corp.

FUSES

Instrument Fuses, also Auto, Radio, High Voltage Aircraft, Neon Potential Fuses and Indicators
Send for catalog
LITTELFUSE LABORATORIES
4250 Ravenswood Ave. Chicago, Ill.